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ABSTRACT

Scientists/engineers from industry, universities, and government met to: review the status of scientific instrumentation in university research laboratories; explore new approaches to alleviating problems within existing budgetary constraints; and suggest ways for the National Research Council (NRC) to help. Federal agency, corporate, and university reports are provided in separate sections. Also provided (in appendices) are testimonies on scientific instrumentation presented to the U.S. House of Representatives Subcommittee on Science, Research, and Technology, and letter reports (including one on debt financing of scientific equipment). Although serious problems in providing instrumentation in university research laboratories were recognized, an appeal for major infusion of new federal funds was not seen as the first priority. Rather, it was recognized that there are natural forces at work in the process of allocating resources that tend to drive the university system toward preserving manpower levels at the expense of scientific instrumentation. Because of this fact, such approaches as centralized research facilities, block funding, risk management, and debt financing at universities were considered. Formation of an NRC action group was also considered, recommending that the group draft a statement encouraging a multipronged approach toward two key objectives. These objectives, and mechanisms to achieve them, are discussed. (JN)

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Revitalizing Laboratory Instrumentation

The Report of a Workshop of the Ad Hoc Working Group on Scientific Instrumentation, March 12-13, 1982

Office of Physical Sciences
Commission on Physical Sciences, Mathematics, and Resources
National Research Council

NATIONAL ACADEMY PRESS
Washington, D.C. 1982

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A complete transcript of the sessions is available for the cost of reproduction upon request to the Commission on Physical Sciences, Mathematics, and Resources.

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INTRODUCTION

In 1970, the National Science Board commissioned a study by the National Research Council of the National Academy of Sciences and the National Academy of Engineering on the status of instrumentation in university research laboratories. At that time, a need for $200 million in new instrumentation was identified. In the intervening decade, the consumer price index rose by slightly more than a factor of three, while instrumentation costs inflated at almost twice that rate. The accumulated need is now at least $1 billion. Some estimates are considerably higher.

About 10 years after the identification of the problem, $75 million was earmarked for instrumentation, but the funding was lost as a result of efforts to reduce the federal budget. An attempt to reestablish the funding through an Interagency Working Group on University Research Instrumentation led by the National Science Foundation achieved some success. The Department of Defense has requested $30 million for instrumentation, and the National Science Foundation's program budget requests for instrumentation have increased an average of 11.5 percent. Programs for instrumentation in the National Institutes of Health will request a slight increase in their budgets. And program officers in the National Aeronautics and Space Administration and the Department of Energy are giving special attention to instrumentation needs. These are positive steps, but much remains to be done.

In October 1981, the President of the National Academy of Sciences and Chairman of the National Research Council convened a conference on the federal R&D budget. One recommendation of the conference was that scientific instrumentation in university laboratories be revitalized. In response to that recommendation, the Chairman of the Office of Physical Sciences within the National Research Council's Assembly of Mathematical and Physical Sciences (now the Commission on Physical Sciences, Mathematics, and Resources) proposed an NRC program initiation effort on scientific instrumentation. The Assembly approved the proposal, and the NAS President granted funding for a planning effort. Its purpose was to define a constructive role for the National Research Council in seeking solutions to the problem.

To carry out the planning effort, an Ad Hoc Working Group on Scientific Instrumentation was formed of leaders of corporate R&D laboratories, university researchers, and representatives of various

government agencies involved in the interagency effort on instrumentation. With internal NAS funding, the Working Group met at the Academy on March 12 and 13. The agenda of the meeting is shown in Appendix A, and the attendees are listed in Appendix B.

The focus of the meeting was on instrumentation costing in the range of $50,000 to $1 million in chemistry and physics and the related areas of astronomy and the life and earth sciences. It was generally agreed that the problem is already well recognized and documented, and no attempt was made to adduce further proof of its existence. The purpose of the meeting was rather to uncover and promote new ideas for alleviating the problem within existing budgetary constraints.

This report, which outlines the results of the meeting, consists of a summary, prepared by the Executive Committee, followed by abridgments of the proceedings of Sessions I, II, and III, the focuses of which were federal agencies, the corporate sector, and the universities, respectively.

SUMMARY

The meeting of the Ad Hoc Working Group on Scientific Instrumentation brought together more than 50 scientists and engineers from industry, universities, and the government with the following goals.

1. To review the status of scientific instrumentation in university research laboratories.
2. To explore new approaches to alleviating the problem within existing budgetary constraints.
3. To suggest ways for the National Research Council to help.

The consensus that there is indeed a serious problem of providing adequate instrumentation in university research laboratories was unanimous. In the long run, this problem could seriously undermine the nation's technical effort, thereby endangering both our security and economic well-being. The Working Group did not, however, conclude on this basis that an appeal for a major infusion of new federal funds dedicated to scientific instrumentation should be the first priority. Rather, it was recognized that there are natural forces at work in the process of allocating resources that tend to drive the university system toward preserving manpower levels at the expense of scientific instrumentation. Because of this fact, the Working Group devoted much of its attention to new approaches to the management of the university research enterprise that could promote more effective use of existing resources. Such approaches could lead to more permanent solutions that would obviate continuing cycles in the status of scientific instrumentation, which would lead in turn to repeated demands for new infusions of federal funds. Nonetheless, it is recognized that a backlog of need has accumulated that should be addressed by the federal government. The group applauded the efforts of the National Science Foundation's Interagency Working Group and in particular the $30 million instrumentation initiative of the Department of Defense.

At the end of the meeting, the university participants and the corporate participants caucused separately; they then met jointly with the Working Group's chairman to report their conclusions. Both caucuses reaffirmed that the problem is well recognized and that there is no need for studies to document its existence further. Both groups recommended the formation of an Ad Hoc Committee on Scientific

Instrumentation within the Assembly of Mathematical and Physical Sciences (now the Commission on Physical Sciences, Mathematics, and Resources) that would organize a series of regional workshops, the main purpose of which would be to inform the university community (both researchers and administrators) of new ways to make more effective use of existing resources. Upon completion of a series of regional workshops, the ad hoc committee would formulate a long-range statement that could provide some stability for a decade or longer.

UNIVERSITY CAUCUS

There was a consensus among the participants in the university caucus that the problem of research instrumentation in universities seriously threatens the health of the scientific enterprise in the United States--in the short term by its direct impact on scientific research, and in the long term by its effect on the training of scientists. The problem clearly warrants the dedication of new funds. However, the university caucus concentrated its attention on various strategies suggested during the course of the workshop for making optimum use of the limited resources that are currently available.

Centralized Research Facilities

It has been suggested that the problem of scientific instrumentation in the universities could be alleviated by greater reliance on centralized research facilities used by a number of institutions in a given geographical area. It should be noted that the concept of jointly used facilities is firmly established in fields of physics requiring instrumentation of very high cost. Examples include oceanographic facilities, computers and other facilities for atmospheric physics, high-energy particle accelerators, and synchrotron light sources. When instrumentation of such high capital cost is involved, there is no practical alternative to centralized research facilities.

An appropriate question, then, is: What are the relative advantages and disadvantages of centralizing less costly instrumentation? On this point the consensus was less general. It was argued that, in some cases, central facilities may provide the researcher with greater flexibility in that he is free to use the facility that best meets his needs. On the other hand, there is clearly no point in centralizing facilities that are already fully utilized.

There are, moreover, more fundamental concerns about increased reliance on centralized facilities. The frontiers of knowledge cannot be moved appreciably with standardized commercial instruments. On the contrary, fundamental advances in knowledge are made with one-of-a-kind instruments, although the support of many standard analytical instruments may be required.

A second serious concern about increased reliance on central facilities has to do with the effect it would have on the training of graduate students. An important aspect of that training has to do with

the interaction among graduate students, particularly across disciplinary lines. Reliance on centralized facilities tends to limit the experience of the graduate student to working with people in areas closely related to his own. Many felt that the scientific community should be reluctant to give up this important educational aspect of research.

Block Funding

Much of the instrumentation problem can be traced to the practice of funding specific experiments. This practice makes it difficult for either the funding agency or the institution to justify the purchase of major items of instrumentation. The most serious aspect of this problem is the seeding of new faculty and enabling established faculty members to undertake major changes in the direction of their research programs. The use of block funding to institutions that can be used flexibly to provide instrumentation is one solution to the problem.

There was a general consensus that certain safeguards must be built into any block-funding program. There is enormous pressure in the administration of flexible funds to provide help primarily to those who have difficulty obtaining support from outside sources. In some cases, such help may be warranted, but it often results in flexible funding being dissipated on less successful researchers. Therefore, there is a need for safeguards, such as requiring matching funds from the institution and annual peer review of the uses made of such block funding. The latter is particularly appropriate in the case of umbrella grants made to cover specific research areas such as materials science.

Risk Management and Debt Financing

There was strong consensus that the universities must show a greater willingness to use some of the alternative financing arrangements discussed during the workshop. Such arrangements enable major items of instrumentation to be financed through direct use charges against the grants, or by inclusion in the indirect cost pool used in computing the overhead in the same way that the construction of research space is financed.

Such arrangements provide much greater flexibility in the administration of funds, thus making possible investment in major instrumentation facilities. At the same time, since no new money is created, the cost must ultimately be applied to some other aspect of the research program. One consequence of this type of financing may therefore be to shift the instrumentation problem from major items of equipment to items costing a few thousand dollars.

Role of the National Science Foundation in Equipment Donations

It has been suggested that the National Science Foundation might serve as a broker for equipment donations by manufacturers. While the university caucus felt that such a program would certainly be worthwhile and should be pursued, it was less sanguine about its having a significant impact on the existing problem.

Workshops and Seminars

There was strong consensus on the need to communicate among all parties involved the real needs of the principal investigators, and the priorities that should be followed in meeting those needs. It was felt that there was a particular need for workshops to educate university business officers and academic administrators in the steps that should be taken by universities to manage their resources better.

CORPORATE CAUCUS

The corporate caucus concluded that the National Research Council should convene a special action group on the problem of obsolete or obsolescent research instrumentation in universities. Its purpose would be to draft an action statement that can be issued to the science and technology press and circulated to cognizant congressional committees or relevant funding agencies. This action group should be representative of the four significant research-performing segments of the U.S. economy: industry, universities, government laboratories (including federally funded R&D centers), and nonprofit research institutes. The statement to be drafted would be a call to action on a single problem for which ample studies combine with individual experience to produce a remarkable consensus: research instrumentation in U.S. universities is seriously obsolete, thereby impairing the quality of a large portion of U.S. basic research and, perhaps worse yet, weakening the graduate training of our future scientists and engineers.

Equipment obsolescence in the universities has been worsening for over a decade. The corporate caucus held that the nature and qualitative extent of the problem are amply established and that further studies are unnecessary. Furthermore, it concluded that this situation has occurred as a natural consequence of the biases and pressures inherent in current research support mechanisms, in traditional procedures of university management, and in ever-more-constrained overall research funding levels.

Therefore the corporate caucus urged that the new action group draft a statement encouraging a multipronged approach toward two key objectives.

I. Achieve a more balanced emphasis on provision of modern research instrumentation through revising the policies, mechanisms, and procedures of research support, management, and financing.

II. Redress the accumulated backlog of need for modern research equipment in universities through short- to intermediate-term special measures.

The first objective is important in attaining the second. The research community can more convincingly seek special "one-shot" remedial measures if it simultaneously offers a program to set and maintain the university research systems in proper balance.

The corporate caucus recommended that the action group consider the following elements for their multipronged program to achieve the two major objectives just described.

1. Creative financing approaches using mechanisms selected from among (a) revenue bonds, (b) industrial development bonds, (c) municipal bonds, and (d) tax-exempt commercial borrowing. These arrangements should be thoroughly explored and considered by every research university. The outstanding achievements of Colorado State University and the imaginative investigations by Harvard University in this sphere are two significant examples.

2. Better university management and planning for research equipment needs. The creative financing mechanisms noted above force some of these improvements, but concerted university planning for research equipment needs, including optimization of equipment investment returns through sharing among departments within the university and among universities in a particular region or urban area, is also needed.

3. Revisions of the Office of Management and Budget Circular A-21 to permit university recovery, through overhead cost reimbursement, of the costs of financing research equipment and facilities. This step would eliminate the necessity for universities to achieve the same end by setting up third-party entities (for example, a university research foundation) from which to lease research equipment.

4. Long-range planning and policy revision within the agencies supporting university research to enable university planning for research equipment purchase and financing. This should include some proportion of block grants or contracts to leading university departments in specific fields, because the block grant mechanism not only makes overall instrumentation planning more feasible but also facilitates equipment planning and procurement in support of promising young (untenured) investigators.

5. Modification of the tax credit provisions in the Economic Recovery Tax Act of 1981 relating to grants of equipment by manufacturers to universities. The new provisions should allow for:

(a) use of fair market value of the donated equipment as the deduction basis,
(b) inclusion of computer software at fair market value, and
(c) expansion to include instructional equipment as well as research instrumentation.

6. Special one-time instrumentation funding initiatives by the agencies, such as the program of the Office of Naval Research. The overall climate may be less than opportune, but there is nevertheless a fundamental soundness to this kind of action, particularly in association with the other steps that give promise of avoiding future decay of the quality of instrumentation.

The first five elements address Objective I; all the elements contribute to achieving Objective II.

The corporate caucus saw the role of individuals from industry as one of not only participating in the action group but also possibly providing subsequent testimony to congressional committees or funding agencies. They could also meet with university groups to discuss industry's experience in funding research equipment, and they could participate in "tutorials" of the kind suggested by the university caucus. Providing the chairman of the action group would be another possible role for the industrial sector.

Regarding the proposal that the National Science Foundation serve as a "broker" between industrial equipment donors and academic recipients and in the process evaluate the quality and needs of academic research activities, the corporate caucus felt that it is quite appropriate for the National Science Foundation to perform such a function. The caucus members were unsure, however, whether many donor companies would want to avail themselves of this service. The transfer of instrumentation would be facilitated if the National Science Foundation provided a list of needs to which industry could respond directly.

SESSION I: FEDERAL AGENCY REPORTS

Frank Press
Chairman
National Research Council

The issue of instrumentation and facilities as an important element in the health of American science and technology is an issue that has been identified and recognized for 5 to 10 years. Consequently, there is no further need to make the case that this is an important national need which, for institutional and budgetary reasons, has not been properly addressed over the last 15 years.

The 1983 budget requests for several agencies attempt, within budgetary constraints, to make available some additional funds through reprogramming to address the instrumentation problem. In time, they will have a significant impact--perhaps not as rapidly as is needed, but, nevertheless, the trend is a positive one.

These are times of budgetary constraint, and we have to be realistic and recognize that. It would not be realistic to make demands for large new sums specifically targeted toward this problem. But creative ideas that open up new possibilities in terms of the roles of industry and government, tax credits, and changed program emphasis in the agencies could all be very helpful. There are many approaches that might make contributions which, while individually small, could be impressive when taken together in their totality. The possibilities opened up by changing tax credit laws should be considered carefully. An industrial firm that transfers equipment to a research laboratory in a university can qualify for a tax credit; but if this transfer occurs for educational purposes only, then a tax credit is not available. There is legislation under consideration by the Congress to correct this imbalance. Industrial leaders and computer manufacturers say that if this legislation were changed, there could be a significant transfer of small computers and other equipment not only to universities but to high schools and public schools throughout the country. This question should be a part of your deliberations.

You all know about the terrible problems we have with precollege science and mathematics training in this country. Not only is there a problem of teachers and curricula, but there is a serious problem,

again, with equipment, and a change in the tax laws favoring donation of equipment might make a very significant impact here as well.

Providing adequate scientific instrumentation in university research laboratories is a very important issue. The agencies are represented here. The different institutions that are affected are represented here. If, working together, you can come up with some creative ideas, then this conference will be eminently worthwhile.

William A. Fowler
Chairman
Ad Hoc Working Group on Scientific Instrumentation

You will find in your packets copies of the statements on instrumentation in university research laboratories made before the House Subcommittee on Science, Research and Technology on March 4, 1982, by Donald Langenberg, Deputy Director of the National Science Foundation, by Robert Scott, Director of the Office of Financial Systems at Harvard, and by myself (see Appendix C). The timing was unavoidable and not all that propitious; I did not have the benefit of the advice of this working group and had to speak for myself. I hope that you will find time to peruse these statements, which serve well as background for our meeting.

I would like to quote from Don Langenberg's testimony:

> There is an emerging consensus in universities, the federal government, and private industry that there is a critical and growing need to replace obsolete and worn-out research apparatus and laboratory facilities in the nation's research universities.
>
> Although its precise dimensions are not known, there is strong qualitative evidence that the problem is pervasive and large in scope. A rough, but reasonable, estimate of the lower level of the deficit is $1.0 billion. Upper boundaries of the problem have been placed in the $4.0-$6.0 billion range.

In my own statement, I pointed out that an NSF/NAS study in 1972 concluded that "the magnitude of the need is easily abstracted. It is large--that is, well over $200 million in spite of the exclusion from the survey of equipment requiring additional staff." In one decade--1972 to 1982--the magnitude of the problem has escalated by a factor of five. It will grow worse if something is not done as soon as the nation recovers from the present period of financial exigency. In my book, that recovery might be expedited by doing something now, and that brings us back full circle to the purpose of this Working Group.

Our purpose in meeting today and tomorrow is to advise the Academies through the NRC as to what role they can play in connection with the critical state of instrumentation in university research laboratories. It was my original intention to look into updating the 1972 NSF/NAS Survey of Research Equipment Needs in Ten Academic

Disciplines. In discussions with agency and congressional representatives, it soon became clear that the instrumentation problem is well recognized and that there is a general, although not unanimous, belief that a further effort to gather data and to document the existence of the problem is not a priority. And there is no financial support evident for such a study. Contributing to this general belief was the fact that an Interagency Working Group chaired by Langenberg had worked on the problem and had formulated a new initiative based on interagency cooperation. You will hear about that in this session. In addition, two excellent reports carried out under the auspices of the American Association of Universities on scientific instrumentation needs of research universities became available in 1980 and 1981. Jack Crowley of the AAU will tell us about these reports in the third session.

In order to make the problem tractable, we have limited the scope of our considerations to instrumentation in astronomy, physics, geophysics, astrophysics, biophysics, chemistry, geochemistry, and biochemistry. Other offices in the NRC are looking at other fields, and we will hear about NRC efforts in the earth sciences this afternoon. Large facilities and space-borne instrumentation are excluded. Primary consideration will be given to instrumentation costing from $50,000 to $1 million. We are concerned with university research laboratories that are aimed largely at graduate student training. Instrumentation built in university laboratories for use at national and regional facilities by user groups is included.

You will note that attendance at the meeting has been heavily weighted toward participation by leaders of corporate R&D laboratories--with correspondingly modest participation from university researchers. This is deliberate. I did not want this Working Group to be looked upon as a means for self-interested special pleading by university researchers. I also place great value on the special insights that corporate researchers can give. Of course, the public sector--namely, government agencies--plays a crucial role in solving the instrumentation problem. I hope that by bringing these three groups together on this problem we will be able to generate some new ideas and some new pathways for communication and collaboration.

It would be counterproductive for me to emphasize too much my own views on what conclusions this Working Group would reach. Suffice it to say that universities, with counsel from representatives of the federal agencies and of corporate research laboratories, must take a hard look at how program funds are currently expended on instrumentation relative to payroll and operating expenses. It may not be possible in FY 1983, but in my mind the eventual solution will require, among other things, dedicated instrumentation funding as an add-on to program funding. In my congressional testimony, I recommended $200 million per year for five years above and beyond program funding.

In Session I, we will hear from representatives of federal agencies who can inform us concerning current administration policies. In Session II this afternoon, we will hear from representatives of corporate research laboratories, who have much to teach us about

research management. Tomorrow, in Session III, we will discuss the issue from the point of view of the university community.

N. Douglas Pewitt
Associate Director for General Science
Office of Science and Technology Policy
Executive Office of the President

The Administration clearly accepts that there is a problem of aging research equipment in research universities in the United States; there is no doubt about that. The problem has serious implications for the nation's future. The Administration does not, however, believe that a major new initiative in this area is possible at present. The 1983 budget request does not contain in it a major initiative for scientific instrumentation. The Administration accepts the fact that there is a federal role in this area and that there is a role for the universities and for other parts of society. Our role will be, for the time being, essentially to assist the universities in addressing this problem within the context of overall research support, which we hope, Congress willing, will be increasing.

Qualitatively speaking, it is generally agreed that the problem exists. There have been attempts to quantify the problem that indicate that it lies mainly with instruments in the $100,000 to $1 million range. We can either start now to begin to address the problem or we can kill time by further attempts to quantify it. But we all know that the problem is a qualitative one. The problem of instrumentation in our research universities has implications for the whole country, both in fundamental research and in limitations imposed on the academic research community. But even more important is the fact that we are educating a generation of scientists who, when they leave the university, suffer the disadvantages that many people from less developed countries feel when they come to work in a technologically advanced country. This hurts us in a broad range of our activities, both in defense and in our industry.

I will touch on the FY 1983 budget requests of the agencies in this area very briefly. The Department of Defense has an initiative on the order of $30 million to build up the university research instrumentation base. NASA program officers have agreed to give special attention to project-related instrumentation requests. The National Institutes of Health have provided a slight increase over the current instrumentation program. The program officers in the Department of Energy will give special attention to requests for instrumentation. NSF research programs will show an increase in major equipment over last year of something approaching 12 percent, to a level of about $95 million. The Interagency Working Group continues to meet on this problem.

Over the period 1972-1980, basic research funds expended by universities have increased by 14 percent. This is based on GNP deflator adjustments. However, at the same time, the number of full-time research and development scientists and engineers employed by

universities has increased by about 24 percent. Obviously, the number of bodies has outstripped the dollars available. This was not something that someone forced the research and development and scientific enterprise to do; it was obviously something we did collectively. Federal, state, and local governments and the universities did it. We have to address this if we are going to work toward reestablishing the same sort of per capita funding that once prevailed. We must also address the fact that there has to be some recognition of linkage; the rates of growth of funding and of people have to be kept in reasonable alignment.

We are very hopeful that the Office of Management and Budget will be coming out with a revised Circular A-21. That will be helpful. The provisions of the Economic Recovery Tax Act of 1981 are also expected to have a beneficial effect.

To sum up, there is a problem. There are no simple solutions. The problem is not one of quantity but rather one of quality. The Administration acknowledges the problem. We intend to play a supportive role. But we are only part of the problem and therefore only part of the solution. The initiatives should lie with the people who have the problems--that is, with the university research community. Solutions will not come from a politically insensitive system. We have to find joint solutions, working together with the agencies and research communities and avoiding confrontations.

Comment, George Pake

I do not believe that the problem was made by the institutions that have the problem. There was always a bias that made it very hard to get capital equipment. It has been built into the system. It is a U.S. societal problem, and I do not hold the universities responsible for the dilemma in which they now find themselves. You cannot expect them to do anything as each budget squeeze occurs other than to try to preserve the talent that they have.

Comment, Marvin Cassman

I take issue with Mr. Pewitt's statement that quantification of the problem is not possible, with the implication that it is not useful. I think that it is extremely useful, because it is not possible to set up a solution without some kind of an argument as to what kinds of goals one should be aiming at in terms of dollar value. You can't simply go in and say let's take 10 percent of the budget without some rationale as to why that represents an adequate number.

There is no absolute number that one can arrive at, but one can make a set of assumptions. As long as those assumptions are clear, one can then derive a number. You can argue with the assumptions, but at least you know where the number comes from.

Comment, Paul Maxwell

How carefully has OSTP been looking at some initiatives that don't require new funds--for example, the proposed changes in OMB Circular A-21? That is a subsidy, but it has the benefit of allowing the universities to act more in unison and to move toward the operating style of large facilities and other large-scale programs that involve more than isolated principal investigators. It tends somewhat to relieve the principal investigator of the responsibility for making personal decisions about personnel, graduate students, and so forth.

Reply, N. Douglas Pewitt

OMB will be coming up with a new A-21 that will correct some of those things, and we have been working with them. If you can identify new approaches like that, let us know, because they are eminently workable. The fact that they have not been done before is unconscionable.

Richard Nicholson
Director
Chemistry Division
National Science Foundation

I am representing Don Langenberg, NSF's Deputy Director, who very much regrets being unable to come to this meeting. There are few other issues to which Don Langenberg has made a greater commitment while he has been at NSF than the instrumentation issue.

There are four issues that we would like this group to look at, and in each case the issues are in the formative stages at NSF. The timing is such that NSF could benefit from your advice. These issues are:

1. What should NSF do in data collection?
2. Is money the only problem?
3. What will be the impact of the new tax initiatives?
4. Should the small-business innovation program be focused on instrumentation?

NSF has decided to try to expand the scope of its statutory responsibility for data collection to include instrumentation, so that in the future one will have better indicators of the status of instrumentation in the United States. The Science Resource Studies Division has conducted a prototype study involving a sampling of 38 institutions. It is now developing a plan for what this data collection and analysis will involve in the future. That is one of the four things I would like to invite this group to comment on--what is it that the NSF ought to do in this initiative?

As to the second initiative, the federal budget for basic research right now is of the order of $6 billion. If we view the problem as

requiring $100 million per year from the federal government, then one is merely talking about a shift of 1-1/2 percent per year in the priorities of the federal agencies funding research. When viewed in that way, the problem does not appear to be insurmountable. How, then, did we get into this situation?

The system operates so as to force a large number of individual choices between butter and guns. In the short term, individuals always choose in favor of people over instrumentation. We concluded in the middle seventies that this was exactly what was happening in chemistry. We came to the view that what Garrett Hardin, in his famous essay [Science 162, 1243 (1961)], called a tragedy of the commons was occurring in the field of chemistry. We made a decision to influence the tradeoff by creating a separate account where a program officer could go if he had a proposal that had a big piece of equipment in it. It all comes out of the same budget, and it isn't new money, but to an individual operating within the system it is perceived as new money, because now he can make a grant with a big piece of equipment in it without jeopardizing the other parts of the proposal. Whether to approve withdrawals from this special instrumentation account is decided internally.

The end result is that the chemistry division in NSF now puts about 20 percent of its budget into instrumentation--that is, for major items of equipment. That is probably three times the national average, if you look at other funding agencies. This illustrates that the problem is partly a behavioral one, as well as a money problem. I do not want to suggest that the money problem is not there--it is both a behavior problem and a money problem.

The third item relates to tax incentives. The Economic Recovery Tax Act of 1981 revised the tax codes in the United States in a number of significant ways, including changes in the codes covering R&D activity. In particular, two sections of the tax law--Sections 221 and 222--speak very explicity to research and development and to the question of instrumentation. Section 222 is clearly intended to encourage the donation of instrumentation from equipment manufacturers to colleges and universities engaged in research. These sections are clearly explained in Lewis Branscomb's testimony (see Appendix C).

In the past, if a corporation that manufactured equipment decided to give a piece of equipment to a university, it could take the cost of manufacturing the equipment as a tax deduction--not a credit, but a deduction. In the new law, not only can the corporation take the cost of manufacture as a deduction but, in addition, it can take half of the markup, up to an amount not to exceed the base price of the instrument. In the most favorable case, a deduction of twice the cost of manufacturing the piece of donated equipment could be taken. A corporation in the 46 percent bracket claiming the maximum deduction can donate equipment at a cost of 8 cents on the dollar. Will this make a difference? Are the equipment manufacturers going to come forward now and donate more equipment than they have in the past? At NSF, we need to know the answer. We would also like your advice as to whether NSF should take an active role in promoting this approach. The National Science Board feels that we ought to and has proposed a plan,

now under development, for doing so. Your advice would come at a very propitious time.

The outline of the plan is as follows.

1. NSF invites manufacturers and suppliers of equipment to participate in a joint program.

2. Each industry participant agrees to donate equipment. A minimum donation may be required. A catalog file listing equipment would be maintained by NSF and made available to program officers and to proposers.

3. NSF accepts, reviews, and makes decisions on research proposals, including equipment, in the normal fashion. If an award is recommended and the project includes a scientifically justified equipment request, the NSF program officer either (a) recommends the award, including NSF funds for the equipment, or (b) triggers instructions to the donor to transmit the requested equipment directly to the grantee.

Is this a good idea or not?

Finally, the fourth item on the list of issues on which we would like your advice is a program at NSF called the Small Business Innovation Research, or SBIR, program. It started in 1977 and is designed to help small businesses engaged in R&D in the United States. Such businesses can submit a proposal during a phase one to NSF, and NSF gets those reviewed, selects a subset, and funds them with a fairly small planning development grant of typically about $30,000. Recipients are to seek venture capital and develop their ideas further. Then, about six months later, in a second phase, NSF looks at those who got phase one grants, decides on a smaller group of more promising requests, and makes a larger grant, on the order of $200,000 to those. As a result of this program, there may suddenly be a lot more money available to support R&D in small businesses. Should NSF narrow the focus of this program to include mainly small businesses that are engaged in activities relating to instrumentation?

We would appreciate your thoughts on these four issues that I have presented to you on Don Langenberg's behalf.

Marcel Bardon
Director
Physics Division
National Science Foundation

We have come to the conclusion in the Physics Division at NSF that the support of basic physics in universities is not only important but that we should do something to see to it that the best work continues to be done. However, it is obvious that funding has eroded drastically and that we must plan realistically with that in mind. The only way to do that for the program managers is to reduce or terminate some existing operations in order to make more funds, more support, and more instrumentation available to the others. We are doing just that.

We have started with nuclear physics. We support 11 university laboratories with nuclear physics accelerators. In a few weeks, two of them will be notified that their support will be reduced with the expectation that their research will shift to the user mode. These numbers should be put into perspective. Fifteen years ago, there were 75 university nuclear physics laboratories; today, there are maybe 20 all together, including the ones that DOE supports. The DOE recently informed two universities that their programs of in-house nuclear physics would be closed. As I indicated, we will inform two more that similar things will happen to their support.

Obviously, this is a very bad situation, but there is no alternative. We have to provide capabilities to the others. We are doing similar things in other areas. In particle physics, some groups will soon learn that they will not be supported or that they have just enough support to travel to collaborate with some other groups, but they will no longer be able to contribute in a major way to the preparation of new experiments.

Other groups, of course, will be able to do better. All this is in line with the philosophy that some groups must have more money in order to use their capabilities for doing research, and we are going to apply that through the other areas in physics.

Comment, Arthur Bienenstock

The technical manpower market seems to have been very volatile over the past 10 years. I remember at Stanford our belief six or eight years ago that we were overproducing engineering Ph.D.'s and that we had better cut back. Now one reads in the paper that one has to produce more Ph.D.'s because industry is taking them all and we have no faculties.

The hardest thing to produce is a cadre of highly trained people. You can produce equipment pretty fast, but it is very difficult to produce people. Before we turn too quickly to guns in the place of butter, we ought to think about doing something to buffer the country against this volatility in the people market.

Alvin Trivelpiece
Director
Office of Energy Research
Department of Energy

I think that it is wrong to assume that there is, in fact, a solution to the instrumentation problem. The instrumentation problem is somewhat like the balance between food supply and population in primitive societies. If a tribal group, living at the margin of survivability, discovers a means by which it can increase its food supply, then it begins to overpopulate and gradually finds itself once again living at the margin. At the new equilibrium, the same number of people are starving to death as before. Similarly, if our research

enterprise is instrumentation limited and many researchers are finding themselves "starving to death" for want of adequate equipment with which to carry out their research, then increasing the amount of available instrumentation will only temporarily alleviate the figurative starvation. If the money available for instrumentation were suddenly to double, you would solve the problem transiently, but gradually the problem would begin to recur and you would be right back at the margin of survivability.

The DOE's style of operation is to try to create large facilities which are then available for a large number of users. Some examples are the National Synchrotron Light Source, the Stanford Synchrotron Radiation Laboratory (which will soon be a part of the DOE complex), the intense pulsed neutron source, the high-flux isotope reactor, the high-flux beam reactor, the new combustion research facility, and the two large electron beam microscopes. We are financing many different things, including large pieces of equipment and beam lines used by many people. There is access to the lab built beam lines, and now there is a trend for the university to build beam lines--and these are very expensive items. You will hear some of the details in the discussion of the Stanford facility in tomorrow's session.

We tend to support instrumentation at about 10 percent of overall program funding. This number is not fixed--it is the result of the phenomenon I mentioned before. This number could be deliberately changed gradually. But it should not be set by us in the bureaucratic mode. The situation can be improved by making sure that all parties understand each others' roles. We are willing to listen and to make changes on these percentages, but it is going to be a zero-sum game, to a first approximation. Is it better to have few investigators with better equipment or is it better to try to have more people using poorer equipment? It is a difficult question.

The DOE has no problem in paying lease charges. If equipment that is needed can be leased, that is perfectly acceptable. And the possibilities for creative financing of equipment should not be overlooked by universities. We have purchased two Cray computers in the last few years at Lawrence Livermore Laboratory by the lease-to-ownership approach. That permits us, using operating funds, to purchase a multimillion dollar object that is, in fact, owned by the Bank of America. Because the university is a 501(c)3 nonprofit corporation, it has certain tax advantages available to it. Those tax advantages have been adjudicated to apply through to the laboratory. Therefore, the Bank of America owns the computers, and we pay the lease-to-ownership costs. When the net remaining amount is approximately 10 percent, then we will pay that as the capital charge, rather than paying the full capital equipment charge for the thing up front.

That kind of creative financing is an ingredient in the solutions that should be sought. We have tried to go in the direction in Basic Energy Sciences of having fewer scientists better equipped. In the 1980-1982 period, the percentage of equipment has gone from 6.6 to 7.3. These are gradual changes. We are willing to increase these figures further, but we need guidance from the research community.

As a nation, in virtually every city, in every endeavor, we are simply eating our capital. It is true of the national highway system, it is true of the water system in New York, it is true of the roads in almost every city, and it was true in the DOE national laboratories to a very high degree. Over the years, the laboratories have deteriorated substantially. This deterioration was quantified and estimated to be on the order of $1 billion of integrated shortfall of maintenance on simple things like roads and transformers. It is on the order of $34 million this year, which is really only a drop in the bucket. Yet when budget time came this year, we were looking at 12 percent cuts. It took a great deal of determination not to simply terminate the maintenance activity in favor of keeping programs alive. The dilemma exists everywhere in the system.

None of these problems has been solved. As a nation, we are eating our capital in so many areas that it is truly distressing. And it is not being fixed, and this is merely one area. It is an area which we collectively have a common concern about, and we would like to see the situation improved. We should make an effort to get our part improved, but the problem is by no means unique to us in this situation.

Leo Young
Director, Research and Technical Information
Office of the Under Secretary of Defense for R&E
Department of Defense

The first recommendation of a recent Defense Science Board report is that there should be support for more instrumentation at universities. There has been a lot of attention paid to this issue.

Historically, there has been a strong interaction between the DOD and the universities, starting with the Office of Naval Research many years ago, which has grown now to include the Army, Air Force, and others. The Defense Department depends very much on the well-being of the universities, and it is important for us to make sure that they are prosperous and healthy. We have initiated talks with university people with the idea that we have to support the universities wherever we can so that we in the Defense Department can benefit from the work that goes on there.

We look to the universities for three things. One is the research itself. Second, we look to the universities for training scientists and engineers. Finally, we depend on the universities to give us independent expert advice. There is a commitment to all of these things, and I want to tell you about what we have done about them. There are three specific things that have come about. One, and it is the biggest in terms of funding, is an initiative on instrumentation, which addresses the main subject of this meeting. Another one is to initiate fellowships at the universities, which would be supported, in part, at least, with instrumentation going for the research that these fellows would be doing. And finally, we are assisting the universities by providing shorter contract forms to speed up the business of establishing contracts.

It is convenient to break instrumentation down into three categories: (1) those that cost less than $100,000, (2) those that are between $100,000 and $1 million, and (3) those that are above a million dollars. The DOD instrumentation initiative addresses instruments in the middle range.

There has been an increasing awareness of the shortage of equipment, and, if you look at the numbers, the percentage of DOD contracts let to the universities that has been spent on instrumentation has risen from about 4 percent in 1978 to about 8 or 9 percent in 1982. So there has been an increased emphasis on equipment within the research contracts. But this kind of equipment is mostly in the first category. It was always difficult to fund the bigger items, and that is why we started the new initiative. In 1982, there is a one-shot infusion of $3 million for equipment for the Joint Services Electronics program alone. The Army Research Office had an initiative for computer resources of between $1-1/2 and $2 million per year, again for FY 1982. About half of that is for equipment, and half is for support of the equipment and research.

The Office of Naval Research will be starting a DOD fellowship program in FY 1983 with about $1 million annual funding. It will include graduate fellowships of about $12,000 per student. For each fellowship, an additional amount of about $8,000 will go to the university, partly for tuition and partly for instrumentation.

The biggest initiative is the one that will start in FY 1983 and will run for five years. We will put in $30 million annually for the five years FY 1983 to FY 1987 that is specifically earmarked for instrumentation. It works out to $10 million per service. In this case, it is not a choice of people versus equipment. As the 6.1 budget (basic research) was being formed, additional money was put in by very persuasive arguing. The research budget was increased at that point by $30 million, rather than taking an existing budget and peeling off $30 million for instrumentation. The visibility had been established by the good work of the NSF, the AAU, and the AAAS, and that helped to sell the idea.

The total contract support in basic research from DOD to the universities this fiscal year is about $300 million. That is roughly half the total research budget. There is about an equal amount of additional support to the university that is not in basic research or development money. So the $30 million a year, in the basic research context, is about 10 percent of the total. If you count it in the other work that is being done, the development work, some of which might be classified, it would be about 5 percent of the total. Sticking with the 10 percent figure for the moment, for five years that amounts to 50 percent, so the total amount of money that would go into instrumentation would be roughly 50 percent of the annual operating budget.

What has not been mentioned is that the equipment that is needed has a limited lifetime. The lifetime is about five years, which is probably not an unreasonable number these days. If we accept the total need as being in the range of $1 to $2 billion, and the total funding for research going on at universities is $10 to $15 billion, then we

are talking about 10 percent or more. So the DOD is contributing its share of instrumentation needed for its share of the work. The numbers are certainly in the right ball park.

How will we administer the funds? Each service will be responsible for how it allocates the money, and it will be allocated in conjunction with research projects that we are interested in. We will coordinate this centrally. We will advertise, and the requests will go to one address rather than to three separate addresses. We will then sit down and form a committee to consider what should be the floor, what is the lowest funding that we will provide so we don't buy very small items, and perhaps an upper limit. We will then divide up these requests that came in among the services and finally, when they have made their decisions, we will get together again to make sure that nothing has been missed and that it works out as a whole.

We will obviously emphasize those technologies and disciplines that are of special interest to the DOD, and we will work with the interagency group led by NSF. It is very important to coordinate and to exchange information among involved agencies. But it would be wrong for a central group to try to direct what these agencies do.

Let me also mention our IR&D program. We would like to use IR&D as one vehicle by which we can extract the good work done at the universities and bring it out into useful products, into innovation, if you will. What we are trying to do now is to encourage industry to put some of its IR&D dollars into the universities, not just as a handout but more with the idea of applying that research to the kinds of products that industry is interested in. We would like to bring the two together.

DOD also has what we call the Defense Small Business Advanced Technology program, which was started last year. It is modeled on the NSF program, and we very likely will start a second phase--DSBAT-2.

Let me turn to sharing of facilities. These days, in many laboratories, we are constrained for people but we have the money to buy equipment. The universities, on the other hand, have the people but don't have the equipment. It seems logical to put the two together. Wouldn't it be useful if we brought either some university professors on sabbatical, researchers on an as-needed basis, or graduate students into DOD labs? This arrangement will establish relationships among people which could be very, very useful.

Finally, let me congratulate the Academies for taking the initiative and calling this meeting. I hope that some sort of plan develops from it.

Comment, William A. Fowler

Is the $30 million for use in university research laboratories?

Reply, Leo Young

The $30 million is strictly to the universities.

Comment, Robert Park

I want to put in one word of caution about shared facilities. That is a great idea in many fields, and in many fields it is an absolute necessity. In many other fields it is simply not practical.

Many of the regional instrumentation facilities that the National Science Foundation created are good research facilities, but they are not regional instrumentation facilities in any real sense of the word.

Furthermore, there is a real question of the quality of education when we move more and more to the shared facility. Graduate students learn more from each other than they do from their professors. We have to keep them together in large enough numbers so that they interact with each other.

Comment, William A. Fowler

I feel very strongly that it is time for some mechanism to be set up so that these problems can be faced up to. We don't have a mechanism for looking at what the consequences are for going this way or that. There is a real need to look, on the part of the universities, with the help of the corporate sector and with the help of the agencies, to the resolution of these problems, setting some goals.

Murray Eden
Chief
Biomedical Engineering and Instrumentation Branch
Division of Research Services
National Institutes of Health

NIH has prepared a report on shortages in research equipment and instrumentation and has a set of recommendations based on its experience (see Appendix C). Within NIH there are two entities that concern themselves with funding instrumentation. In the National Institute of General Medical Sciences, there have been for some years programs that emphasize instrumentation. The NIGMS, in FY 1979, began a program of distributing monies for shared instrumentation. This program is for instrumentation costing from about $40,000 to $150,000.

There is another entity in NIH called the Division of Research Resources. It has had for some time an ongoing program under the title of Biotechnology Resources Program. This program provides biomedical investigators with access to large-scale equipment in the physical sciences--including resources for computation--and the kinds of devices include NMR spectrometers, high-voltage electron microscopes, computer systems for graphic display of biological structures, and X-ray diffraction systems. There are only a few devices peculiar to biomedicine. One example is the flow cytometer. These are devices for determining the size and other physical properties of individual cells within large populations. There is a very exciting set of developments that are more medically oriented; in particular, there are imaging

devices that have important research implications. The ones that are getting the most publicity now are the nuclear magnetic resonance imaging devices and positron emission tomographic scanners. These are expensive devices--on the order of $1-1/2 million.

Let me return to the programs themselves. The DRR, in addition to its Biotechnology Resources Program, has proposed and has announced the beginning of a biomedical research support program in FY 1982 called the Shared Instrumentation Grant Program. It has a budget of $3.7 million and has proposed a $5 million budget in FY 1983. The nature of the application covers instruments costing from $75,000 to $250,000. They have requests for about $39 million in applications thus far received--about 1-1/2 percent of the NIH extramural budget for research grants.

SESSION II: CORPORATE REPORTS

Peter Jesson
Director
Division of Physical Sciences
DuPont Central Research Department

We would be remiss in not addressing what I would call the boundary conditions of the research funding problem as well as the specific problem of instrumentation. If we look at the R&D funding for nondefense research within the United States, we must ask whether the total expenditures are appropriate relative to our international competitors. If they are adequate on a percentage of GNP basis, then the instrumentation problem must arise from the distribution of funds between people and equipment. Perhaps a redistribution is all that is required.

We do have a number of DuPont-university interactions. We have had long-standing unrestricted grants programs to a number of universities, and we have more recently got into specific interaction situations that many of you will know about--for instance, the life sciences interaction with Harvard. We have had concerns about things like the chemical engineering training situation, which was mentioned earlier, and we have instituted some steps to try to help. We also have activities going on in which DuPont provides funding for joint research. I am not sure that any of these things is going to grossly alter the financial picture as far as the funding for instrumentation is concerned. There is an instrument problem, and the question is how does one deal with it?

We have to deal with very similar instrumentation problems internally within DuPont, which is composed of a fairly large number of almost autonomous departments. There are seven of these at the moment, with names like Textile Fibers, Petrochemicals, and the like. There are also two major staff departments which are involved in R&D--the Central Research Department, which I belong to, and the Engineering Department. Each of these has to operate in some way within the total corporate context, and the total funding available is finite.

Instrumentation is used in a variety of ways, corresponding to almost all the ways suggested for providing instrumentation to universities. Possibilities range from situations in which each

investigator asks for his own equipment to situations in which instrumentation is integrated to serve some broad mission for which it is essential to centralize analytical facilities.

Within the Central Research Department, we are organized along five lines, four of them major science areas: Life Sciences, Polymer Science, Catalytic Science, and Materials Science. There is a separate analytical division which is responsible for providing analytical services. There are on the order of 300 assigned technical people divided almost equally among those five areas, although life sciences is expanding rapidly, and there are about 300 nontechnical people supporting them.

We do keep a clean separation between the operating budget and the capital budget. The capital budget is divided into three sections. It consists of equipment costing (1) from zero to $75,000, (2) from $75,000 to $750,000, which roughly corresponds to the equipment that we are talking about here, and (3) above $750,000. A typical departmental situation might be that the budget for the first category is roughly 8 percent of the operating budget, the budget for the second category is 4 percent, and the budget for the third category is variable, usually involving a major expansion of facilities.

To summarize the DuPont situation, we have a departmental structure which in some ways leads to the same kinds of situations that one has between different institutions in the academic community. We do assign equipment over a broad range of functions, from centralized analytical facilities to individual investigators. We operate on a capital budget basis.

What are the tradeoffs involved in the organizational use of the equipment? We do not go out of our way to make sure that the equipment is used 24 hours a day. In principle, at least, dispersal of the equipment would appear to lead to maximization of expense and minimization of utilization. That is not necessarily so. If you try to centralize things, you immediately introduce a lot of other problems. There are problems of feedback, problems of the operator involved. Is he skilled enough in the area that you are interested in? Does he have his own research program which has conflicting demands for time on the equipment? Is there an expertise problem? Does it lead to conservative science in the sense that the equipment will not be modified extensively? You will probably not purchase equipment for use in a central facility with a particular area of research in mind; you will purchase it with a more general kind of perspective. Does centralization lead to low-risk experimentation because you are removed from the experiments or you don't want them to fail? Clearly, it also leads to an access problem in terms of hands-on operation.

So it is by no means obvious that centralization of equipment is the most efficient way of doing it. To sum up, we are faced with a fixed amount to divide in this area, and one has the question of the most efficient use. That gets down to questions of regional facilities versus individual investigators. We wrestle with similar problems. They are difficult problems. We have no magic formula at DuPont.

Finally, there is the question of whether expanded funding is needed for instrumentation. I urge you to face directly the question

of whether the total R&D funds being committed are adequate, as opposed to looking at instrumentation funding in isolation.

Comment, Arthur Bienenstock

At Stanford, about 20 of the faculty are organized as a result of having had a Defense Advanced Research Projects Agency materials research laboratory which eventually went over to the National Science Foundation. Consequently, we can make expenditures every year in the $100,000 to $1 million category as a result of being block funded. We may want to consider the virtues of block funding of organizations of academic scientists at institutions, because that is a mechanism for getting large sums of money at one time.

Comment, Richard Werthamer

I would like to underscore what Art Bienenstock said. It is a very key issue. The Stanford synchrotron source is an expensive piece of equipment which dominates the whole laboratory's enterprise. There is a management structure, and the management cannot afford to have that equipment poorly utilized, so there are allocation decisions as to who is going to get in there and get what time on it. Furthermore, the proposals are probably screened for the adequacy of equipment that the scientists propose to bring. There is a drive toward a management-administrative structure to make sure that everybody is properly equipped to do the best work. That is perhaps less true with an individual investigator acting independently.

Reply, Peter Jesson

I have roughly 60 Ph.D.'s in an organization which is centered mainly in the area of catalysis. It would be very shortsighted of me to get myself in a situation where I had too many people and not enough equipment for them to do the job that we are trying to accomplish. In my own self-interest, I have to make sure that the people I have are adequately provided with instrumentation. If a tradeoff has to be made, then that must be borne in mind.

George E. Pake
Vice President for Corporate Research
Xerox Corporation

I would like to underscore, following up the previous remarks, that in my experience in the academic world, the really successful departments or academic programs almost always have had at the core some kind of block group. This arrangement is exceptionally useful in providing funding for bright young people. That allows the department to decide

in rational ways on allocations of resources, which can't always be done if the compartments are too small. That is very important.

That is a natural lead-in to what I want to say about Xerox research. Xerox corporate research, for which I have responsibility, is one big block grant each year, if you will, from the corporate management. We tend to break research up for purposes of discussion into basic research followed by applied research, then followed by two kinds of advanced development. What we do in advanced development inside the research organizations I call exploratory development. We have an organizational boundary at that point. I have responsibility for the activities I just described, and they are called corporate research at Xerox. The operating business units pick up with what we will call advanced development, and they move on to product development and, of course, product manufacture. In many ways, the advanced development in a product unit is very much like the exploratory development in my unit.

It has been typical that Xerox spends about 5-1/2 percent of its revenues each year on RD&E. IBM gets closer to 6 percent. Hewlett-Packard spends about 8 or 9 percent, but it sells more through jobbers and we have our entire internal sales force. You have to be careful of what is in the revenue stream that you reference to.

Of the $500 million that Xerox spends on RD&E, the part for which I have responsibility in corporate research is about 16 percent, or $80 million. That number is a little under 1 percent of corporate revenues. If we fell far below that, I think it might, on general principles, be increased, because there is a feeling that we should invest something like that amount in the future. You can't prove that that is the right number, and it can be debated, but historically we have accepted that figure.

Senior management reviews the program that I bring forward for those $80 million, but there is a part of it that they do not review. About 15 percent (we are trying to raise it to 20 percent) is basic research. We don't do basic research in fields of science that are irrelevant to Xerox. But once we decide that the field of science is relevant to Xerox, we do not control what the investigator does. We try to hire outstanding investigators and let them research what they think are the key issues in that field of basic science. Sometimes we guess right, and sometimes we are wrong. For example, we do not have any biochemistry research. In the long term, that may be wrong. We concentrate on physics, chemistry, computer science, and materials science.

The other 85 percent of the $80 million breaks down to something like 65 percent applied research and perhaps 20 percent exploratory development. These programs are reviewed by the management. I take in a description of these programs twice a year. I describe my long-range research plan in the spring and the two-year rolling budget in the fall. The latter evolves from the previous description of the six- or seven-year plan that we have done in the spring.

There are lots of questions. Are we investing in the right things? It is all very subjective, but we try to involve the management in those discussions, even though they are not technical people.

Our operating costs are about $100,000 per year per person in the research organization. There is a separate capital budget for approvals during any given year. The capital budget flows through as a depreciation item in future years to my operating budget, which forces me to consider special capital items very carefully to avoid future problems. For example, we depreciate computer equipment over five years, and in the first year, depreciation plus a corporate asset charge amounts to 40 percent. Buying computing equipment hits my budget very hard the next year.

For my $80 million budget, I have a capital budget for the kinds of research equipment that we are talking about. There is no limit on the dollar size of the item, so it also includes items costing less than $75,000. I have a budget of about $8 to $10 million--it is probably closer to $8 million for the kind of equipment that we are talking about.

It is clear to me from my trips back to the campus where I am a trustee that faculty now spend about one third of their time hustling money and handling paperwork. I now get unsolicited inquiries about employment in my research center from faculty members at absolutely first-rate institutions who say they are interested in coming to my institution because I have much better equipment and a better environment in which to do research. It used to be the other way around--that is, when I was in academic science, we continually got offers from industrial labs that would pay us higher salaries, but we didn't accept, because in those days we had good equipment and a good environment in which to carry out our research. But things have changed.

I have observed that equipment costs inflate more rapidly than any other cost I have in my budget. The fact that more of the equipment is digital compounds the difficulty for me because of the phenomenon I mentioned earlier. In the current economy, I cannot envision corporate growth sufficient to cover those increased costs. I may have to reduce the number of people doing research in order to be able to manage the depreciation charges already incurred. There may be a difficult problem just around the corner for industrial research groups, unless their managements can understand the problems and allow more flexibility.

I want to say a word about my concern for the competitive position of U.S. industry relative to that of other technically advanced countries such as Japan. They seem to have arrangements that put them in a better position to make investments in the future. My race is with Japan, and to keep up in that race I have to have first-rate equipment and first-rate people. You university people have to educate those people, and research using first-rate equipment has to be part of that education.

My view is that rather than getting obsolete equipment like battleships out of mothballs, it is much more important to invest in modern apparatus for the laboratory. By the way, one battleship left in mothballs would probably solve our problem.

Finally, I want to say a word about tax credits. At Xerox, I have had an experience that indicates to me that the tax credit has to be

made more attractive to be effective. You can effectively take a markup of a factor of two as a maximum. But high-technology industry normally takes a bigger markup than that over raw manufacturing costs, which comprise only a small fraction of the total price of the instrument. For software, the raw manufacturing cost (the cost of replication) is essentially negligible. For software, the development costs dominate, and there is no way to recover those. The one thing that I can take to my senior management and make a good case for is instructional equipment. I can make a better case for that than for research equipment. But instructional equipment is excluded in the present draft of the law. I see a number of flaws in the law. It is a step in the right direction, but the details have to be reworked.

Comment, John Holmfeld

Why isn't there a very strong incentive on, say, department heads in universities if they are going to publish competitive science and have their faculty members be at the forefront to, in fact, acquire the best equipment and give equal priority to that?

Reply, George Pake

There is, but they have no mechanism to do it.

Richard Werthamer
Science and Technology Department
EXXON

Exxon spends about $600 to $700 million a year on research and development, which places us about tenth in Business Week's roster of research-performing companies. Within that $700 million for research and development, about 12 percent goes to fundamental research with corporate sponsorship. We consider our Corporate Research laboratories to be doing fundamental work in the sense that it is looking at properties of nature at the molecular level, but directed in the sense that the research is aimed at supporting the businesses that we are in.

The capital budget for the Corporate Research laboratories, although it is a number that is easy to obtain and does convey some information, must be viewed with caution as a measure of equipment intensivity. It also contains such items as laboratory construction. There are relatively small or recurrently needed equipment items that appear in the operating budget. But the capital budget is still the best indicator I have of how equipment intensive our research is. Over the last five or six years, the ratio of capital budget to operating budget for Corporate Research has averaged about 9 percent.

The scientists at EXXON are supported by centralized services. For example, out of our total Corporate Research operating budget, about 6 percent goes to analytical services charges. About five or six years

ago, we recognized that our analytical division was underequipped for current and projected needs, and it has since been carrying out an intensive capital purchase program. Whereas the capital-to-operating-budget ratio for Corporate Research is 9 percent, in the analytical division it is running 13 percent.

Capital budgeting is a bottoms-up process in which individual scientists each year formulate what they need for their research. Then there is a committee of middle managers which reviews the list intensively to assure that need. Finally, the capital budget is reviewed at the top management of our research activity and the top management of our corporation, and it may be modified to reflect a more strategic view.

We are presently surveying the instrumentation on our capital roster to determine the degree of use. A preliminary look is giving us some comfort that what we have is really being used and is needed. The majority of the instrumentation in Corporate Research is only a few years old: less than a third was purchased more than three years ago.

R. L. Melcher
T. J. Watson Research Center
IBM

Many of the things that Drs. Pake and Werthamer said apply equally well to IBM research. The numbers are slightly different, but our mission is defined roughly the way theirs is. Our approach to capital funding on a per man basis from the bottom up is very similar to their process.

I plan to give you an outline of a study that we carried out last fall to try to determine if the IBM Research Division has a problem with the way it was doing capital funding. Let me say that the Research Division of IBM takes about 10 percent of the total IBM R&D budget, so roughly $160 million, and involves a couple of thousand people. Each person costs about $100,000 per year. Our mission is science and advanced technology. About a third of what we do at IBM Research is indistinguishable from academic research. The rest is advanced development or exploratory development.

In our study, we tried to understand the capital needs of our division as we define our mission--how they change with time, what is the impact of inflation on what we do, whether the capital equipment has an impact on the type of technical work or the quality of technical work we do, and how significant an impact the work has.

The methodology we adopted was first to find out if we had a problem. We did that simply by sending a questionnaire to all the project managers in the division. We did a rather extensive survey to determine the inflation rate for the type of capital equipment we buy, which is probably indistinguishable from the type of capital equipment any of these gentlemen buys, or for that matter from what is obtained for a typical university. Then we reviewed what our response over the last five or six years had been to that, and we came up with some recommendations for the division.

The results can be summarized as follows. Capital is, indeed, a very significant problem. We asked the researchers to rank capital, manpower, space, support services, expense money, and so on as they affect their performing their job. They answered that manpower is number one. But capital was number two. I will have some comments to make about the relative leverage of capital on their performing their jobs later on. They told us, and it is not surprising, that capital affects their productivity, that is, the quantity of their work, but it also affects the quality of their work. That is, new capital gives them new function--the ability to measure new things. Finally, they say that the lack of capital can distort significantly the type of research they can do. It inhibits them from going into new areas.

In order to determine the inflation rate for capital equipment, we gathered together a market basket of typical equipment that we buy in the division. We compared its cost in 1975 and 1981. The question we asked was not, given this piece of equipment in 1975 and the same piece of equipment in 1981, what was the cost differential. What we asked was, given your business in 1975 and given your business today, what did it cost you to maintain state of the art in 1975 compared to what it cost you to do so in 1981. Any other comparison was irrelevant to what we were trying to find out. Our market basket consisted of roughly 126 items and their cost in 1981 dollars was $13-1/2 million, so we had a fairly significant market basket.

What we found was that the inflation rate for scientific equipment was 16.4 percent per year. Compare this with some of the other studies which have quoted 17 to 22 percent per year. The consumer price index (CPI) over that period inflated at about 9.9 percent per annum, and so what we are calling the scientific price index (SPI) inflates on a per annum basis at a rate about 70 percent higher than the CPI. When one compares capital expenditures from year to year, one should use the SPI rather than the CPI, which is irrelevant.

So we are in an environment in which costs are increasing dramatically. If we deflate by 16.4 percent the operating budget for capital equipment over this time period from 1976 to 1981, we see roughly a 35 percent decrease in the buying power of the individual IBM scientist over that period of time. We felt that that result was revealing and that something should be done to rectify the situation.

What can you do about it? It is important to note that the amount of money actually allocated to equipment that a researcher uses is a very small fraction of the total cost of doing research. In our case, it has been about 5 percent (not including data processing, which we get from IBM on a rental basis). This is a relatively insignificant amount, and when you consider that researchers say that it has a very significant impact on the way they work, it clearly does not pay to overemphasize economies in the equipment budget. We recommended to IBM corporate management that a three-year correction program be instituted to get the capital budget back up to where we thought it should be. The corporation has accepted the first year of the program.

We also recommended that when they go into a major new technology development program (for example, Josephson junction switch technology), they should consider the equipment needs for this program

as an add-on to the existing capital budget, because it is clear that many new dollars for capital will be required to implement such a program.

Comment, Harald Enge

I just want to emphasize that in university nuclear physics research we have experienced exactly the same thing that you are talking about. As an example, Van de Graaff got a grant of $5,000 to build his first electrostatic machine. The Oak Ridge heavy ion facility, which grew directly from Van de Graaff's invention, cost around $25 million. More recently (about 12 years ago), we built a magnetic spectrograph at MIT for $25,000. Today, a corresponding instrument would cost about a million dollars.

Comment, Arthur Bienenstock

Someone ought to point out that a lot of the things that have gone up in cost are, in fact, items which, for the total society, have brought an immense increase in productivity. You are getting things like large-scale integrated circuitry development out of it. It is true that the capital costs have risen at a rate much higher than inflation, but for the total society the costs per bit of information have gone down enormously. This is the one area where we have experienced a vast increase in productivity.

Porter W. Dobbins
Manager
Technical Services Operation
General Electric

Funding of capital equipment requirements such as equipment and buildings for research and development is becoming increasingly difficult in all sectors of our society. This includes governmental and industrial laboratories as well as those in the academic area. Equipment and related facility requirements are consuming a rising share of total available resource dollars.

Several factors combine to drive these costs skyward. Inflation is higher for equipment than for most other resource elements. Advances in state-of-the-art equipment are so significant in productivity and capability enhancements that we don't normally replace worn-out equipment in kind. These added capabilities have a price tag. As equipment grows in sophistication, with embedded microprocessors for example, maintenance becomes more complex and expensive. These same equipment advances are also contributing to more rapid obsolescence of installed equipment. All R&D participants are enveloped in a constantly widening circle of equipment demands with their concomitant high costs.

These problems are most acute in the academic community. Traditional university funding sources and techniques are simply inadequate for today's environment. Government grants, both at the federal and state levels, are being reduced. As a result, contract research funds are becoming more closely tied to program work elements and results. This restricts equipment acquisitions. Saving ahead to purchase equipment is at best a difficult alternative with today's inflation rates. Tuition cannot rise in sufficient proportion to help in the capital funding crunch.

While practices surely vary considerably from institution to institution, I believe that diffused responsibility for allocation and sourcing of capital resources may be reducing both the effectiveness of buying and using equipment.

Statistical information on 15 universities supplied to us indicates that special research equipment needs and funding represent only about 13 percent of these universities' total capital requirements during the period 1982-1984. Thus it is clear that universities, government, and industry must all cooperate to seek solutions to the academic research capital problem.

Let me suggest a few ideas for consideration.

First, universities should review their capital resource planning and allocation process by asking some questions. Does the university have a formal planning and allocation process for research equipment and related capital facilities? Is it sufficiently coordinated or centralized to ensure the best utilization of capital equipment and minimize duplications? Are capital requests evaluated and prioritized based on the total institutional goals rather than a single department's influence? Do capital equipment requests include cost-benefit factors or other economic measures for evaluative purposes? Should they? Are capital equipment needs and costs incorporated in resource plans or budgets of individual departments in support of R&D program proposals? Who controls research equipment? Does it belong to the university, the department, or the individual staff member? What is the best administrative process to foster increased use of shared or pooled equipment within the institution, or even among neighboring institutions? Would further centralization help?

Second, universities should actively promote consortium arrangements and cost recovery between institutions and, where possible, with industries and government. This can be inconvenient, but it's absolutely essential for large investment-intensive equipment. For example, our Research and Development Center is using the Cray supercomputer service at the University of Minnesota, a linear accelerator at the SUNY Albany campus, synchrotrons at Stanford University and at Brookhaven National Laboratory, and molecular beam epitaxy and electron beam equipment at Cornell University and Rensselaer Polytechnic Institute, respectively.

Third, and very importantly, there should be a concerted effort to change the federal tax laws to encourage equipment donations to universities. This can be accomplished by a single amendment that would change the donor's basis for a tax credit from his own book value (the first cost less accumulated depreciation) to fair market value.

Many university people view the provisions of the Economic Recovery Tax Act of 1981 regarding equipment donations as too restrictive. For example, for new equipment the act allows only 50 percent of normal margin for tax contribution value. It also restricts donations to equipment that was manufactured within the past two years and that does not contain purchased parts valued at over 50 percent of the equipment's tax cost. If these restrictions were removed and the manufacturer were simply allowed as a tax credit basis a fair market value equal to his best commercial price for the piece of equipment to be donated, the incentive to donate would be increased significantly.

The 1981 tax law created further disincentives for donation of used but relatively new equipment. Book value--the present tax credit basis--now reaches zero in three years rather than five to eight years as under the previous law. For instance, the tax credit basis for a three-year-old piece of equipment under the 1981 law is zero, whereas under the prior tax bill the donor's tax credit would be about 40 percent of its first cost, assuming that it was being depreciated over eight years on an accelerated basis. Incentives for donation of used equipment--especially reasonably new equipment--would be greatly increased if fair market value, as determined by an independent appraiser, were allowed as the donor's tax credit basis.

Fourth, pressure should also continue for allowance by the federal government of interest costs, or some cost-of-money factor, in costs recoverable under OMB Circular A-21. Such reimbursements will become even more necessary in the future as academic institutions have to resort to new financing sources.

Lastly, new and innovative funding sources and financial arrangements should be developed and evaluated to supplement present grant, donation, and saving-for-the-future arrangements. George Olson, Vice President for Research at Colorado State University, has a number of financing and leasing alternatives that he will discuss in the next session. Colorado State has proven by the magnitude of its installed equipment that tax-exempt debt financing arrangements such as revenue bonds, industrial revenue bonds, municipal leasing, or even leveraged leasing are alternatives that universities should consider.

The Economic Recovery Tax Act of 1981 provided for what is termed safe harbor leasing. That means a company not having income against which to take tax-deductible credits, such as depreciation or investment tax credits, can lease equipment and eventually take title to the equipment for a nominal payment at the end of the lease. The normal lease usually requires payment by the lessee of a fair market price at the end of the lease. Since universities similarly have no income against which to offset depreciation, this should also be a possible source of financing to them, assuming an amendment to the tax act could be passed to make this option possible. This leasing provision may be modified, or could even be canceled, because of its windfall effects in the business community. But this financing option in any surviving form ought to be made available to universities through changes in the tax law.

Debt financing or leasing offers businesslike approaches to the problem. They can be communicated logically inside the institution to

the staff and outside to knowledgeable investment institutions or local governmental authorities. Debt financing will usually require all users to share in the repayment of the debt. This should enhance opportunities for full cost recovery on all contracted research. Debt financing and cost sharing will also instill a constructive discipline in the resource planning and allocation process.

Responding to an earlier question about how management policy is set, we, like the others, have a very definite, formal, bottoms-up program planning process that starts at what we call either the unit or program level up through the various R&D operations. We have four different R&D operations--one in materials, one in chemicals, one in electronics, and one in energy. We have about every discipline represented. They have different approaches, although we try to get them to conform.

Comment, Robert Park

I think I perceive in your remarks a slight misperception of how research goes on in universities. Earlier today, someone alluded to the "wildness" of the way we proceed, but that is absolutely essential. Every professor is an entrepreneur. He is responsible for raising his own money, getting his own grants, hiring his own employees, finding his own students, and deciding which research direction he is going to take, and he can take any research direction he pleases. He can change fields any day he wants. These are problems that you don't have in industry.

I actually don't see it as a problem. In fact, I see it as the strength of the American university research program. It is what we do differently and what we do best. If we know what research we are going to be doing, we shouldn't be doing it. We can't plan years in advance. The kind of planning we can and should be doing is to plan how to have the flexibility within our organization to let us respond to the changes that are taking place in science and society. That is the kind of planning that we need. We don't need to plan what research we are going to do; that takes care of itself, and should take care of itself. There is no idea of long-range planning in the same sense that there would be in a corporate laboratory.

As to evaluation, the only evaluation we have is at salary time. If the faculty do poor research, they get small increases. There is no other real evaluation that is going on--they are being evaluated by their peers constantly, and this is an egocentric bunch of people who are anxious to be evaluated well. That is the driving force. But we don't sit down in any systematic way and evaluate. As a matter of fact, if we followed the provisions of A-21, we probably couldn't even share equipment, and, fortunately, that, I hope, will be modified. One of the tendencies has been that in federal grants more and more it becomes a contract in which you specify precisely what you are going to do and what resources you are going to put into it. Of course, that is inimical to the total process of basic undirected research, which is where we should put the major emphasis in universities.

Comment, William A. Fowler

I agree that we can't tamper too much with the planned anarchy in the university, but this problem that we are looking at--instrumentation costs relative to operating expenses and payroll--might be helped if the universities would take a look at what is being done in the corporate sector.

Comment, Robert Park

I agree; in fact, that is why I was so struck by the comments on the distortion of research that can go on by even small limitations in expenditures for capital equipment.

John Schwamb
IBM Instruments

I am responsible for finance at IBM instruments, and I was asked to talk about the terms and conditions that our company offers in the analytical instrument business and to give you some perspective on the options that might be available to universities.

It appears to us that the vast majority of acquisitions--in fact, over 90 percent of them--are outright purchases rather than other approaches. Payment is usually in cash. Frequently, there is insufficient funding, and that leads to a great deal of discounting, which is unhealthy. Obviously, the industry can't do much product development with low margins. And service provisions seem barely adequate.

Now I would like to discuss our current offerings and give you an overview of some various terms that generally are associated with lease contracts.

Obviously, you can purchase the instrument. We give an educational allowance of 5 percent.

An IPA is an installment payment agreement, and we offer two versions of that. If it is a commercial account or a university that is not funded by the state or local municipality, we ask for a down payment of 25 percent. The interest rate changes monthly--it is now down to about 18. You can pay it off over four years maximum.

State or local customers have to put only 10 percent down. We give an attractive interest rate to state and local governments. Up to five years are allowed for payment. You can terminate the lease at the end of a fiscal year without charge if funds become unavailable and, of course, the instrument is returned.

If universities were interested in leasing instruments, they might explore two types of lease contracts--either a full payout lease or a term lease. The term lease can be from 30 days up to five years. For a full payout lease, you can either exclude the cost of ownership or you can include it. Generally, on a full payout it is what is called a net lease. It excludes the cost of ownership and it excludes service.

The price on that lease is generally fixed. Generally, you don't have a termination privilege.

With a term-lease arrangement, you can either include or exclude ownership or service. Many customers prefer to include service. The price can either be fixed or there can be a ceiling. Many companies have a provision for a 5 percent per year increase. The "trap door" provision means that with this arrangement, if the price goes above a certain level, then the customer can terminate the agreement without penalty.

I would like to make a few observations about the Economic Recovery Act. We do not see any real benefit to the universities of this provision unless they lease the product from a profitable corporation. The safe harbor provisions do not apply, and herein lies the key to any real advantage for the universities. We did work out some examples, assuming that a private corporation were to buy an instrument and donate it to a university and, rather than transfer title in the year that it donates it, lease it over a period of time. The idea was to see what kind of an impact that might have on the private corporation from the cash-flow point of view, since cash is very tight today. The end result is that it does help the corporation's cash flow if it wants to donate items to a university in this way. But there is some administration involved, and you would have to sit down and overcome an obstacle like that.

Comment, John Holmfeld

There has been a noticeable lack in this field of studies by disinterested parties. Some of the existing studies are very much predisposed toward finding a problem. On the question of quantification, it is puzzling that in this particular area the brightest people we have in the country are unable to come to grips with this question in quantitative terms. None of the studies I have seen, for example, attempted to define obsolescence. The anecdotal evidence has been very helpful. No one doubts the veracity of these anecdotes, but we need to know their representativeness. It is very important for this group not only to emphasize in its recommendations the need to provide short-term solution to the problem but, also, to indicate--certainly to the committees of Congress--that whatever suggestions you have are also directed at the longer term.

Instrumentation is being given attention in research project grants; it is being focused on. It is very puzzling that, beginning two or three years ago, it is suddenly being proclaimed a calamity.

Any solutions that you come up with should also address the question of what the impact of your solutions might be on the instrumentation industry. To what extent is goldplating a factor? To what extent has the instrumentation industry in this country adopted the annual model philosophy of the automobile industry? The small fraction in the Congress that is not sympathetic will ask those kinds of questions. I would urge you to pay attention to the unsympathetic fraction, because it will be as loud as your friends.

Jerome A. Smith
Technical Director
Office of Naval Research

There is no question in my mind that this problem is real, and I have observed it firsthand and have sought to stimulate activity in this direction.

The Office of Naval Research is the Navy's spigot for all Category 6.1 funds. That today is a $276 million appropriation in FY 1982, hopefully going to $314 million in FY 1983. Only 62 percent of it is put into the Contract Research program. We are talking this year about something like $140 million of activity in the universities. Another big chunk of our money goes to the Naval Research Laboratory, and the other Navy laboratories get another $30 million--NRL gets almost $60 million. About $140 million out of the $160 million Contract Research program goes to universities.

We have taken a concerted action to increase the amount of Navy funding for equipment targeted specifically at our principal investigators. In fact, since FY 1979, when we spent $9 million in equipment of a budget of about $110-115 million to universities, we have increased it to $14 million last year out of $125 million going to universities, and expect to increase this to $17 million this present year to $19 million next year.

In addition, next year, as a result of an initiative which you heard described by the DOD this morning, we will be spending $10 million for research equipment. So we expect our FY 1983 expenditure for research equipment in universities to be approaching $30 million next year.

The $19 million, which has been a regular part of our Contract Research program, has been exclusively used to support our principal investigators on a usually relatively small level. We have not been able to buy very many large pieces of equipment with that. With the new $10 million instrumentation funding, we expect to go into joint funding arrangements with universities, state governments, other DOD agencies, and NSF, chipping in on these larger equipment buys. The key difference is that those equipment support proposals can be derived from direct solicitation to the DOD, to ONR, for equipment only, as contrasted with it being a part of an ordinary research proposal.

Our intention is to apprise our principal investigators of the opportunity in July and encourage them to review their needs. I expect to see proposals coming forth any time between July and the end of this calendar year, and we will expend the money over the fiscal year.

The other thing that we are doing that may be worthy of note in this group is the ONR Graduate Fellowship program, which addresses the personnel shortages that we see. We have, in the same FY 1983 budget, a million dollars this year--it will be $2 million in 1984 and $3 million in 1985, if we get the congressional approval--to establish a graduate fellowship program which will provide stipends of $12,000 a year and three years of support. The university will get $8,000 on top of the $12,000, part of which could, in principle, be used for instrumentation to support the graduate fellow's research. Support

will go for areas that we deem not only critical to the Navy but in short supply from the standpoint of U.S. citizens. We can put in place over the next five years something of the order of 150 to 200 first-rate, star-quality U.S. citizen researchers in the areas that we are identifying.

William Luth
Office of Earth Sciences
National Research Council

The Geological Sciences Board pointed out that there was a problem in instrumentation regarding specifically the geological sciences. We use the same techniques that the materials scientists do. We rely very heavily on advances in instrumentation and data collection capability from physics and chemistry. We have formed a subcommittee of the GSB to look at the problem and have met twice with the subcommittee. We have prepared a questionnaire to be submitted to a number of earth science departments in the country. This is perhaps the first illustration of what I consider to be the nature of the problem, in that we found that there are in excess of 100 departments that grant earth science degrees of one sort or another at the Ph.D. level with 10 or more faculty. To outfit them adequately is clearly beyond the nation's capability.

We are asking for information not only on what they have but also on how well they use it and how well it is maintained. The most important thing coming out of it is that there will be a way to coordinate and to make sure that all of the various activities concerned with instrumentation are well informed.

SESSION III: UNIVERSITY REPORTS

Harry Gray
California Institute of Technology

My role is to discuss the instrumentation problem in chemistry. I am Chairman of the Advisory Committee for the Chemistry Section of the NSF. I have also been associated with the Office of Chemistry and Chemical Technology at the NRC and I am the Division Chairman at Caltech in Chemistry and Chemical Engineering, and I have been spending a great deal of my time in the last few years raising money for instrumentation, not only in my own lab, but in laboratories of younger colleagues, in shared facilities--everything you can think of--so I think I understand the problem pretty well.

The chemistry community is coming from a slightly different place than the people in physics, who have been used to big instrumentation for a long time. Chemists are a tougher bunch of characters who tend to fight and to squabble a lot, don't trust each other the way physicists trust each other, and are basically small-time operators.

As far as I can tell, physicists, in reviewing proposals, always say good things about each other, while chemists tend to go out of their way to find bad things to say about their colleagues, and this does have an impact on funding and it certainly has an impact on raising money for instruments. And I say it only half in jest.

What has happened in chemistry with the incredible revolution in, say, analytical instrumentation is that now there is a whole standard set of instruments for graduate training and graduate research and undergraduate training as well. There is a whole set of instruments that are absolute musts in major research universities. The fact is that we are just running behind, and have been running behind for some time, in acquiring these instruments and in renovating older ones. The problem is not so much one of funding. It is more a problem of cutting through the time to acquire instruments, the time to review proposals, the duplication in the review process, and so forth in research programs in chemistry, because the chemists are coming from this small-time operator frame of reference.

So a chemist who has a good research program typically comes in and spends a great deal of time psyching himself up to ask for $50K, when over a two- or three-year period he needs $100K for instrumentation,

and it takes him three or four years to psych himself up to ask for $50K. That is the nature of the problem, as I see it, in chemistry. The results are what we see now, namely, the deterioration of the research universities, the sad state of instrumentation in chemistry, and, in general, a significant retrenchment compared to our European and Japanese colleagues, so that even chemists are considering more and more going to Japan and to Europe to do state-of-the-art measurements.

Let me give you some hard numbers. In the Chemistry Section of NSF, we have been taking money for some years right out of our hides to support instrumentation. We have recognized this problem for a long time. The question is, what are we doing?

We put about $4.5 million straight out of the chemistry budget--that is out of just the program budget--into instrumentation. That is not an instrumentation line item in the NSF budget that is right out of the program funding. We target it for instrumentation, essentially on a 50-50 university-NSF matching basis.

So, if you have psyched yourself up to ask for $50K and you can get $50K to match it, then you can get a $100K instrument. Typically, two, three, or four university professors will get together and write a proposal. They will spend several weeks, possibly two months, writing a proposal for a $100K instrument for programs that have already been peer reviewed and are already going. I think that is an incredible waste of time, and that is my first point.

We end up funding, in the NSF Chemistry Section, about 40 instruments a year in this country, 40 instruments a year at about $100K each. The actual total impact on the country is double this $4.5 million that Chemistry is putting in. So, it is like $9 to 10 million in instruments out of our hides. Our need is about three times that. That is, in order to get the analytical instrumentation just for the graduate training of the order of magnitude stuff we are talking about, we should be putting right now about three times that, or about 120 instruments of this type a year, the smaller ones, into the major research universities.

There are two results. One is that the young people in chemistry are having a rough time. The second is that the established people are spending far too much time writing proposals. They are writing proposals two or three times. They are writing proposals once to justify the program; they are writing a second proposal for the instruments, and a third, and a fourth, and so forth, and that is absurd.

I think if it is peer reviewed the first time and it is a good program, there ought to be some mechanism by which you can inject the funds for the instrumentation into the health research programs, and the health research programs can certainly be judged by the agencies. It seems to me there is a mechanistic problem involved. Without any new money, there is a mechanisms problem, and if the agencies and universities could get together and solve it, I would like to see them do that.

What I am suggesting is that we are about four or five instruments per department per major university behind, and we have got to have a mechanism to inject that instrumentation in without waiting five or six

more years, and without waiting for something that is not coming, namely, a lot of new money. And there is no way industry is going to make up the difference.

The universities are going to have to look at their programs and look at how much they are putting in people and so forth. Everybody is going to have to give on this one.

We have talked about this problem for the last eight years. We know the problem exists. And we keep falling farther and farther behind, even though the funds are actually there. The funds are actually there if we just figure out how to put this ball together.

In chemistry, my estimate is that we have got to find some way to inject in the next year-and-a-half into the major research universities about $20 million worth of equipment of this type. That is not a staggering amount of money. That can be done with the universities coughing up about half of that. What I would like to see is the NSF and DOD and NIH coming up with the other half; that is not unrealistic.

James Ebert
Vice President
National Academy of Sciences

I think it would be a serious error to push harder toward regional centers for a number of reasons. I think, first of all, the regional center concept is a valid one--it is being used effectively, I do believe--but what we need most is money for instruments of the kind described here, and chemistry is just the tip of the iceberg.

Molecular biology, the earth sciences, a broad range of fields have needs far beyond yours. I consider the amount of money you suggested, $20 million for, say, the next year in chemistry, absolutely trivial. I think you are off probably by at least $80 million for the first round on chemistry. I realize that that poses a problem, but it might as well be said straight out right now.

The regional concept does some other things badly. It doesn't really encourage creativity of two kinds. It doesn't encourage creativity in the adaptation of the smaller instruments. Most of these $100,000 to $200,000 instruments come in through a good laboratory, and they are modified by the people working with them in one way or another. You end up so that the instrument being used by a small group of people becomes a very different and often very special instrument, and you create a great deal more good research in that way. Secondly, the regional centers do not encourage interactions between fields. If you look now at the movement between the earth sciences and chemistry, for example, this is an enormous active interface, and this kind of interface is promoted much more effectively when you have the instruments located on site where these people can get together.

John Crowley
American Association of Universities

I came to this issue following a 1978 meeting of the AAU Committee on Science and Research, a committee of eight university presidents. When the committee was formed, I asked them to identify AAU priorities in the broad area of science and research.

They immediately came to a conclusion without much discussion at all. The overwhelming priorities of the AAU in the area of science and research, in addition to a stable research base, are instrumentation and facilities and people. With that direction, we proposed to NSF in 1979 a study of instrumentation needs in universities.

The report was completed in 1980, and I guess most of you have seen it, or have seen the 1981 Science article that summarized it. Following that, we did a small, modest survey of research facilities' needs. It was a mail survey of about 15 or 16 universities asking them to document what their facilities' needs are in essentially the same fields we looked at when we did the instrumentation report for the NSF.

Let me tick off some of the key findings, first, from that instrumentation report, which is the one that I guess has gotten more notice than any other. The median age in the university labs of the equipment surveyed turned out to be about twice that in the commercial labs we looked at. The basic conclusion was that the stuff is just worn out. In a large number of universities across the disciplines surveyed, we have an acute obsolescence problem.

There are other contributing problems in the areas of acquisition, start-up funds, support equipment, and operation and maintenance. There is a backlog of need for facilities, construction, and renovation. Also, we constantly bumped into the need for teaching equipment. Every place we turned, every institution, most of the departments we visited, raised with us the question, "Don't you want to talk with us, as well, about our teaching needs?" We said, "We are really charged with the research instrumentation, the analytical stuff." And they said, "We really want to tell you about the teaching equipment." That was so consistently raised with us that we culled it out in our letter of transmittal to the NSF as something that really needs attention. In many departments, they placed equal emphasis on the backlog teaching needs and pointed out that they had been kind of bootlegging teaching equipment money to support the research enterprise over the years, and they just can't do it any more.

We gave the report to the NSF in July, and the timing was at that time, we thought, just fine. In August, Frank Press announced the Carter Administration's special $600 million R&D initiative, which was to be a supplemental to the budget. It included $100 million for instrumentation in the NSF and $25 million for engineering instructional equipment. That did appear in the final Carter budget in 1982, and in making the announcement Dr. Press indicated that this little report had something to do with it.

It fell immediately under a ban by the Reagan Administration against any new program starts. It is a political ban, in my view, not an assessment of the seriousness of the problem. It was described, I

thought, carefully by Dr. Keyworth and the NSF and others as a deferral, not a rejection.

The report also was transmitted to the various congressional committees that have responsibility for the NSF, DOD, DOE, and NIH, and on April 3 of last year we made a major presentation to the House Armed Services Committee. We had a panel of five university presidents and a vice president from IBM who testified, and that contributed directly to the report that Leo Young mentioned yesterday just completed by the Defense Science Board on the responsiveness of universities to national security needs. In that report, there is a fairly extensive discussion of the universities' backlog research instrumentation and facilities needs, and I think that contributed to and directly shaped the $30 million program which is now in the DOD 1983 budget.

While we are talking today about instrumentation, it seems to me we cannot divorce the research instrumentation question from the broader question of research facilities, which have been seriously eroded over the years and are the other side of the coin. We have enormous backlog of need in the country for replacement construction, for new construction, to completely, in some cases, gut and rehabilitate the laboratories that are housing or will house the new instrumentation.

The instrumentation report recommended strengthening the project system. We did encounter, wherever we went, an immediate concern that whatever would happen as a result of this would in some way diminish the project system. The competition within the project system for people support and instrumentation support came time and again, and the project system, it did seem to us, has to remain the backbone of the support system. The institutional funding has to be provided, in our view, within the individual projects for instrumentation.

We need to expand special programs for instrumentation. We need to create, we thought, a special supplemental program pretty much along the lines of the proposed NSF initiative that was later deferred.

I am inclined to take both a short-term and a longer range view. The problem has been accumulating for probably about 15 years. Therefore, I am inclined to break it apart into a question of short-term tactics and objectives and longer term strategies.

Let me talk for a minute about the short term. We heard yesterday about the $30 million in the 1983 DOD budget request. That $30 million has an importance to this issue disproportionate to the amount of money involved. It is the first year of a five-year $150 million plan in the DOD, which is spelled out in the DSB report. That report was written at the direction of the House Armed Services Committee staff, who told me, and then their Senate colleagues confirmed, if you get it in the Administration's budget and it is well justified and we accept it, you have got something that might last a decade. We have an enormous amount riding on that $30 million and it is not automatic. There are tremendous pressures, as you know, on that DOD budget this year. There was, as some of you probably know, a late-hour rescue of the DOD research lines just before the budget was signed off this year.

If we lose that $30 million, we are going to jeopardize the next four years in DOD; we are going to send, it seems to me, a signal to the Congress and to the DOD that the community is able to identify a

problem, but we can't deliver. OMB is likely to interpret that, if it happens, as a loss of budget authority. That means they could have put those funds someplace else in the DOD budget and gotten them appropriated. DOD is leading an effective effort in this area, and other agencies are being encouraged to work toward comparable initiatives in 1984. So we must resist any attempts to undercut the DOD initiatives.

Arthur Bienenstock
Director
Stanford Synchrotron Radiation Laboratory

The Stanford Synchrotron Radiation Laboratory has thrived reasonably well over the past 8 or 10 years primarily because of support from the Materials Division of the National Science Foundation and the Biotechnology Resource Program of NIH. Nevertheless, from the very beginning, or almost from the very beginning, the laboratory had immense help and pushed forward on a rapid scale, as a result of collaborations involving both people and money, with people from the corporate sector and from government labs. It is those collaborations which I have been asked to describe here today.

From the very beginning, we were heavily dependent on government lab support, on Xerox support, and on Bell Labs support in order to build up the instrumentation. We made deals in order to obtain this support. The scientists who built up this equipment got about 50 percent of the beam time on these lines for two years. That was our mechanism for paying them back, for the money and for the immense intellectual effort that led to the establishment of these lines when there were no precedents in the world for this sort of instrumentation or utilization.

What happened? Soon thereafter, the United States developed a major program in synchrotron radiation. Two storage rings, one for vacuum ultraviolet and one for X-rays, were funded at Brookhaven. Those laboratories are under construction now. A larger storage ring for the soft X-ray and vacuum ultraviolet was funded at the University of Wisconsin and is under construction now. Finally, facilities were established at an existing storage ring at Cornell. So there was an immense expansion of funding for bending magnet synchrotron radiation in the United States in approximately 1977.

In about 1978, there was a dramatic development which had an immense influence on the field. That was the development of "wiggler" magnets. The wigglers that we use now have eight poles. At all wavelengths, they give a multiplication in intensity of a factor of at least eight. Since, in addition, you can make the magnetic fields very strong, at the photon energies in the X-ray region you have a spectral shift to higher photon energy, so in some of those wavelengths you get an increase in intensity of two orders of magnitude. This means you can just do things that are impossible at the previous intensity.

The next development, called an undulator magnet, has many poles. It gives a very spiky spectrum, and we again got increases of the order

of 200 to 300 in the intensity, now in the softer X-ray region. Such a device also produces an extremely highly collimated beam, with almost the collimation of the laser.

These two devices started to change our whole attitude toward the generation of synchrotron radiation in about 1978 or 1979, so that in 1980 we found ourselves in a new situation. We saw ourselves with the opportunity for about two orders of magnitude more intensity or brightness than we could previously get. That meant necessarily that we could do new experiments that were just impossible with the previous systems. On the other hand, we had spent all our expansion funds. In the meantime, we had developed our bending magnets and our wiggler magnets, and the nation itself was heavily committed to bending magnet synchrotron radiation facilities. There seemed little federal funding available for new initiatives.

So what do you do when you want to do something and you don't have the money for it? We developed partnerships to further develop the capabilities of SSRL with Xerox and the National Science Foundation and a Stanford group which had Department of Defense money through ARPA to build one vacuum ultraviolet and soft X-ray line with three experimental stations to use three undulators. That beam line, when it is built, will have immense brightness compared with anything else in the world.

Similarly, we formed a collaboration with Exxon, and with the Lawrence Berkeley Lab, that is funded by the Department of Energy to build two X-ray vacuum ultraviolet lines with three to six experimental stations. Now, instead of the eight-pole wiggler I showed you before, we are going to 75 to 125 poles, and we will come out with another order of magnitude at least, or possibly two, of intensity over our existing wigglers in these collaborations.

The cost of these beam lines is $1 to $2 million, which puts them just at the edge of the things we are talking about today, but in fact the cost for an experimental station is right in the middle--it is about $600,000. Our own contribution to each of these endeavors is between 10 and 20 percent of the total cost.

What are the ground rules on these collaborations? First of all, the groups that are constructing the lines and paying for the lines get priority time; a third for the commercial concern, a third for the university group, and a third for SSRL's general users.

There will be a review of the quality of the program during the third year, the quality of the scientific program, a review of the contributions of these outside groups to Stanford's educational programs and research programs, and a review of their contributions to general user support.

There are mechanisms for proprietary research. They are complex and I won't describe them here. One of our biggest concerns is to have organizational and financial arrangements that avoid the potentiality for property taxes. It is a serious concern for our university, and we got immense help from the NSF general counsel on that problem.

The next question I want to address is how generalizable are these experiences. It seems to me that industry will provide support when otherwise unobtainable important capabilities become available as a result. I think that every university at this time seeking to do

something extreme in capabilities should see how that capability will benefit American industry and seek support and collaboration, both financial and intellectual. I have to stress that both were involved in developing SSRL's capabilities. Obvious possibilities are high-voltage electron microscopes and high-field nuclear magnetic resonance. I am sure those of you in the room will think of others, and so will the American scientific community when it thinks about this possibility.

I should mention that these large shared facilities offer graduate students experience in state-of-the-art instrumentation on a scale that they are very unlikely to see at other places. Another feature that is very rarely talked about but is very important is interactions with famous scientists, outstanding people in the field, from other institutions. That has had an immense effect on our place.

Often our students gain access to industrial equipment on the basis of those interactions. I should also point out that there is an immense interaction among disciplines at the laboratory. People meet together on the floor and work together, but the facilities are really rough on graduate students. It doesn't give them the opportunity to make the mistakes that they learn so much from in the laboratory. In that sense, I dislike training my students at SSRL.

George Olson
Colorado State University

If we assume that there is $5 billion going to be spent in university research this year in this country, and we decided to buy $1 billion worth of equipment at 14 percent interest rate retired over five years, it would cost us $291 million, or 5.8 percent of our budget. Now, we can't staff up and buy a billion dollars' worth of equipment all at once this year. So suppose we bought it over five years. Incidentally, the 5.8 percent is about half what we heard the industrial labs spent. We would spend $200 million a year at 14 percent for five years. That is $58 million a year, or 1.17 percent of our budget. I submit to you there is not an equipment-funding problem; there is a university management problem.

I, for one, am opposed to the equipment initiatives as announced by the Department of Defense and NSF. I personally think, and I have spent a lot of time on the Hill, that it is easier to sell research and tell Congress what that does for health, defense, technology, and innovation than it is to sell another gadget which they can neither pronounce nor comprehend.

I am here because I think we have taken at CSU a different approach to equipment financing. One piece of equipment serves as a good example of what our type of financing has done for our institution. Since 15 years ago, when the CDC 7600 computer was the top scientific computer in the world, not one American university ever acquired one. Several were located on university campuses in Europe. My institution presently owns a Cyber 205--it is coming on stream this week--and we own the Cray computer at the National Center for Atmospheric Research.

I think to have taken a jump from no university having a class IV computer to two being owned by a small institution in the Rocky Mountain region that should make you want to listen to how we did it.

The acquisition of scientific equipment ought to be pursued by universities the same way it is in industry. The free enterprise system has given us all the mechanisms and procedures. We have, in addition to their conventional borrowing mechanisms, revenue bonds, IDB's, municipal leases, and tax-exempt lines of credit. What are the advantages of debt financing? Well, first of all, it provides equipment now, so you do scientific progress now and not at some future time. Second, our tax-exempt interest is almost always less than the inflation rate and certainly less than the SPI we learned about yesterday, so you are never going to buy it cheaper, including the interest, than if you buy it today. It does a lot for the university administration. It makes for better management, program awareness, and sensible planning of replacement.

A revenue bond is a device, tax exempt by law, by regulation, or by IRS ruling. It can be issued either by a government subdivision or an agency like a research foundation on behalf of a university. Let me give you an example of a revenue bond and I will show you a bond a private institution can do. We have done a lot of revenue bonds. We did our CDC 6400 with a revenue bond. Here is a typical example of what we have done for a laboratory facility. Interest was approved and we charged the entire cost off to the federal government. It is tough until we get some changes in A-21, but it can be done. We now charge all interest costs to our contracts and grants. What can a private institution do? It can use an IDB. We used the IDB for the Cray computer. It is issued by a city or a county on behalf of someone else. It could be a direct lease between, say, NCAR, or if they don't have experience in financing, you can do it through a third party, and that is where we came into the picture, as a CSU research foundation, and we had the county issue the bonds for us, bought the computer, and leased it to NCAR.

Here are the details of the purchase of the Cray-1 computer for NCAR. It is essentially the same thing we are going through right now with the Cyber 205 computer for our campus. This financing was offered by Cray research at 16.2 percent in 1977. We did it at 6.2. We saved NSF about $2 million in this financing, so we not only acquired it, we acquired it at a lower cost. We then worked with Lawrence Livermore Lab and Jim Queen and John Fitzgerald and took them step by step through a municipal lease on the first Cray with United California Bank.

I think for this group one of the most important things is a municipal lease. A few years ago, the municipalities in this country, the IRS, and Congress got together and created municipal lease legislation which permitted a municipality to go forward with some capital acquisition without going to the electorate and getting a bond issue, a vote, every time it wanted to buy a fire truck, a garbage truck, or improve a sewage plant. They never fail. Municipal leases are great.

But they are canceled every fiscal year, and they must be canceled so they are not a bonded indebtedness of the community. Well, what happened? That just made them fit A-21 beautifully.

We do not incur a material interest in anything our foundation leases to the university, because we make all the leases cancelable every fiscal year end. Well, we went to all kinds of things, you know, satellite tracking stations for our atmospheric science department--I think the really classic financing that we have ever pulled off is we actually figured out we could save a bunch of money by taking a paid-up lease on our NOS operating system inside our two Cyber computers. We even sold a municipal lease on that.

I can show you people how you can charge all the interest to your contracts and grants, and John Lordan and all the people at OMB can't do anything about it. We just completed the audit through June 1981, $110 million, and they passed all of these, so it is safe.

I think, though, it could be simpler if we did not have to use an affiliated organization such as a foundation or institute affiliated with the university--you know, they proposed this in 1981. We sent out over 500 letters trying to get support from the academic community and the instrument manufacturing community to support that. We have done the same thing now in January 1982, and I hope they finally come through allowing interest without going through the Mickey Mouse of a third-party lessor who writes a year-to-year lease. This is important. You must recognize use costs and research contracts in grants, and we must amend ERTA-81. Here is what safe harbor rules were prior to ERTA-81, here is what they are now (see Appendix C). These were really great. They gave you a three-year depreciation for equipment, and, 200 pages later in that bill, they say it only applies to Section 38 property, which doesn't apply to universities. They did say mass commuting vehicles. We are trying to get an extension of this so they treat us like a bus.

What that means to me, as I mentioned yesterday, is that it would save me $6 million on the acquisition of my Cyber 205. I could finance it at zero financing cost with no investment tax credit with no real dollar impact on the federal government. I just spent Wednesday with Dick Perlmutter of the Senate Committee on Commerce and Science at the invitation of Senators Dole and Harrison Schmitt on this very subject, so it is getting attention.

What can industry do to help? Well, it can do direct equipment grants, but historically they have been allowed to give us up to 5 percent net after-tax income and it has been running less than 1. I don't look for a great deal of that. American industry, you know, on the bottom line doesn't make a lot of money--4 or 5 percent in a major manufacturing industry. And you want to get some of that? I think it is unrealistic.

I think what we ought to do, and we have been promoting this with the good help of Control Data Corporation and Exxon Corporation, is to try to explore the opportunity of establishing a national scientific equipment trust that would provide a block of money that would buy bonds for positron emission tomography equipment.

We need somebody who knows what that equipment is and will invest in it and receive a fair return for their investment--no gifts, no grants, we pay our way. If they can't do that, then I would like to see a letter-of-credit guarantee program. They would only pledge their

credit, American business and industry, we would pay them 1 to 2 percent, the standard fee for letters of credit, and it would let us rate our bonds and sell them on today's market at a couple of points less than we have to pay.

Robert Scott
Harvard University

I would like to spend a moment or two discussing why I think universities as institutions have gotten themselves into what I would call sort of a management soup here, and how we have failed to respond effectively, in general, though you just heard a wonderful example of people who have done a better job than most.

The problem, I think, is that universities aren't really, in general, very good at capital planning. Now, we heard a great deal yesterday from industrial organizations concerning the way in which they make productivity decisions and make investment decisions in order to improve productivity.

Universities don't do that type of thing very well. We have heard one particular example, I remember, yesterday, from the gentleman from IBM, who discussed the factor of 30 improvement in the way chemical measurement was made. That is tremendously important to an institution, whether it is a university or a corporation, because of the productivity.

On the other hand, in the corporate environment, where all of the inputs and all of the outputs are being measured, it is more obvious that you can solve a problem by an investment. What I mean by that is, if I am doing a whole lot of those measurements, if I have got a lot of staff time invested in the measurements, if I have a pool of capital that is available for a capital investment, and if I know my capital investment is so many dollars, I will be able to reduce staff time; I make an intelligent, forward-thinking decision in the context of my normal budgetary process.

Universities don't operate that way. We all know within research laboratories that individual pieces of equipment are bought with productivity in mind and with the immediate needs of science in mind, but we tend not to think about the ways in which the entire laboratory could be equipped and could be financed. Universities just don't do this very well, and universities have got to learn to do a great deal better.

The second problem is that universities tend to be capital-poor. They don't tend to make investments in themselves, and they tend not to think in the sense of amortizing capital investment costs over a period of time. That is a bridge that Colorado has clearly crossed, and once you cross that bridge, you make a great step forward.

Let me give you an historical example. In the early 1960s, all computer service at universities in general was provided by either university computer centers or regional computer centers--small computers essentially didn't exist. Those computer centers were generally provided as resources by the university. The costs were

financed by grants or by the university itself, and the usage was rationed in some way. Over the two decades since then, two things have happened. One, of course, is the technological advance in computing equipment which also made alternatives to a centralized computing facility available. But for those people for whom those alternatives are not available or not appropriate, the share of a central facility is still an asset, a way in which things are done. But because of the cost of financing and because of the loss of support from agencies such as the National Science Foundation, general facilities support for things like computing centers has gone away. What has happened, of course, is that they have all been put on a pay-as-you-go basis. Everyone who submits a grant and who requires that sort of service is generally going to put in his grant so many hours of computer service. He thinks of it as a perfectly normal operating expenditure..

There is absolutely no reason why exactly that same approach can't be taken for a large amount of equipment, just the way George has described. What are the problems and benefits of this, from the point of view of the university as an institution and from the point of view of the scientists who are doing the research and who are the beneficiaries of the productivity improvement and the ability to do better science?

I think the opportunity is that the scientist who approaches this problem with a budget in which a fraction of the budget is going to be spent for equipment is going to make a better decision, is going to go to his business officer at the university and say, I can allocate some fraction of my budget for a lease payment on this piece of equipment and that is going to improve my science in this way. My risk is that the university is going to be acquiring a piece of equipment which may not be cancelable because of the cost associated with making a lease cancelable.

I looked a good bit into the way in which we at Harvard have financed our capital facilities other than equipment, that is, the buildings in which the research is done. I think there is a lesson to be learned there. We have, excluding our medical school, just for the sake of argument, approximately $130 million invested in the buildings in which sponsored research is done. About a quarter of that space is devoted to sponsored research, so something on the order of $30 million of space, let's say, is devoted to research. About a third of that cost has been recovered over a period of time through the overhead (the use allowance and the depreciation) but the remaining two thirds has not yet been recovered.

So we have an that investment of some $20-or-so million in these facilities we need to recover. We have incurred that cost and we are going to have to recover it, but I don't see why as an institution we can't incur a fractionally greater cost or risk and be good risk managers, to use your term from yesterday, in order to provide the right kind of equipment when failsafe leasing can't be accomplished.

All of this sounds like a very good complete solution to the problem, but of course it is not. There is a great need for us to encourage, I think, federal investment in equipment for special kinds of programs where the cost is extremely large and where, in a sense,

the investment decision in the equipment is perhaps a major part of the science itself. The example given by the synchrotron lab at Stanford is a very good example of that. However, the approaches that you describe, I think, are very good particularly for the smaller pieces of equipment and for facilities which are maybe not really very small, but which are generally usable pieces of equipment in which an exchange market could be arranged, in which a lessor could find a different place to place the equipment at the end of its useful life to the university.

Another aspect is that I think if we can operate more in this way as institutions, we can show ourselves and the Congress that we are acting to solve the problem where we can solve it ourselves, and we can ask most for help and assistance in the areas where we have most difficulty in solving the problems.

Comment, Robert Park

Like anyone who has been living on a faculty salary for several years, I understand debt financing a little bit. I am impressed with this kind of wizardry, and we have been following what George Olson has been doing for some time in trying to persuade our university to take the same kinds of bold steps.

This sounds great to me. But, you know, I also understand conservation laws, and it doesn't create any money, and in a sense it doesn't create any equipment. It allows you to acquire certain kinds of equipment that you might never be able to acquire in other ways because you can't get that many dollars together at one time.

When you do that, it is going to put the problem somewhere else. It is going to shove the problem right down to the smaller pieces of equipment. So my guess is that after a few years of this--don't misunderstand me, I think we all ought to be doing better management of our resources and I think these are tremendous steps forward--but I suspect that one effect of this is going to be, if it becomes widespread, that the equipment problem is going to be shoved down to the lower cost items of equipment.

Reply, Robert Scott

If we follow this type of approach, the money is on someone else's balance sheet, not on the grants balance sheet for a while, and as we move into writing the equipment off we have a period of time during which there is a great, financially based wizardry and, perhaps, benefit. But there is a potential difficulty at the other end, when the benefit of not having to make all of the capital expenditures up front is gone, that if operating funds are reduced, then the level of equipment would reduce. Yes, that is a risk.

Comment, Arthur Bienenstock

But you have spoken against the federal initiatives for instrumentation. In fact, for the scientific community that offers an opportunity for us to not wait, and I don't think it is wise for you to speak against that because you have an alternative plan.

Reply, George Olson

I think if we have the federal initiatives of another big $50 million push, in five years we will all be in this room moaning about the same problem because we have got our big push out of Congress. I think we ought to face up to the fact that university administrators have got to start doing better capital management planning and solve this problem every year.

Comment, Arthur Bienenstock

There is another option. What you are saying is that we should do long-term planning via debt financing. There is the other option of the agencies responsible for funding scientific instrumentation planning with the scientific community so that this problem does not recur.

Comment, George Olson

I am just playing the devil's advocate. Believe me, mine is the worse of the two alternatives. It is always better to have somebody give you the money and buy the equipment. Believe me, that is always better. But I come from a school that just can't get that equipment, so we have to do it some other way.

Reply, Robert Scott

One of the things I maybe didn't stress as much as I would have liked to is that I really believe a mixed strategy is necessary. I think for the kind of equipment you are talking about, the national definition is needed but for Professor Gray's example of the equipped chemical laboratory, I think the approach we are talking about at this end of the table may be far more appropriate, or certainly an alternative to consider, particularly when you think of the productivity improvement of your colleagues not having to write the bloody proposals.

Comment, Harry Gray

There is probably no chance that this country's university administrators can shape up the way you suggest and figure this out

except for a few isolated cases where there are some smart people involved to figure the problem out. But it is not going to solve our problem just by making that statement, and I do honestly think that stated opposition to these equipment initiatives will hurt us overall. I think we are going to have to take mixed strategies. There are going to be some university administrations that are going to be able to tack this on the front end and go at it in this imaginative way, and I think that is great.

There are also going to be some universities that can't handle it.

[See the Summary for reports of the University and Corporate caucuses and the executive session in which their deliberations were discussed.]

APPENDIX A

AGENDA OF THE MEETING OF THE AD HOC WORKING GROUP ON SCIENTIFIC INSTRUMENTATION, MARCH 12-13, 1982

Friday, 12 March 1982--Lecture Room

08:30 Registration

09:00 Introductory Remarks--Frank Press, Chairman, NRC

09:05 CONVENE MEETING, Review of Purpose and Scope--William A. Fowler, Working Group Chairman

09:30 Briefings and Discussions--Concerned Agencies

09:30 Federal Agency Initiatives and Activities--N. Douglas Pewitt, OSTP
10:00 Richard Nicholson, NSF
10:30 Alvin Trivelpiece/James Kane--DOE
11:00 Leo Young--DOD (see ONR below)
11:30 Murray Eden--NIH

12:00 LUNCH--Refectory

13:00 Briefings and Discussions--Industrial Research Laboratories

George Pake--XEROX Palo Alto Research Center
Peter Jesson--DuPont Research
Richard Werthamer--EXXON Research
R. L. Melcher--IBM Research
Porter Dobbins--General Electric Research
John Schwamb--IBM Instruments

16:30 -- Office of Naval Research

16:30 Jerome A. Smith, Technical Director, ONR

17:00 NAS Activities

Office of Earth Sciences--William Luth, Sandia
Office of Chemistry and Chemical Technology--(See March 13 agenda)

17:30 ADJOURN

17:45 Reception--Rotunda

18:30 Dinner--Great Hall

Saturday 13 March 1982--Lecture Room

09:00 RECONVENE, Review of Briefings--William A. Fowler

09:30 Scientific Instrumentation in University Research Laboratories

Harry Gray, California Institute of Technology (OCCT)
John Crowley, American Association of Universities
Comments by James Ebert, Vice President, NAS
Arthur I. Bienenstock, Stanford Synchrotron Radiation Laboratory
George Olson, Colorado State University
Robert Scott, Harvard University

11:30 Caucus of Industrial R&D Leaders--George Pake, XEROX PARC--Board Room

12:30 LUNCH -- Followed by Adjournment of Ad Hoc Working Group

13:30 Executive Session--William A. Fowler--Room 180

15:00 ADJOURNMENT--Executive Session

APPENDIX B

ATTENDEES AT THE MEETING OF THE AD HOC WORKING GROUP ON SCIENTIFIC INSTRUMENTATION, MARCH 12-13, 1982*

Mr. John Andelin
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APPENDIX C

TESTIMONIES ON SCIENTIFIC EXPERIMENTATION

Testimony of William A. Fowler, California Institute of Technology

Testimony of Robert Scott, Office of Financial Systems, Harvard University

Testimony of Lewis M. Branscomb, Chairman, National Science Board

Testimony of Donald N. Langenberg, Deputy Director, National Science Foundation

Testimony of Robert L. Park, University of Maryland

STATEMENT

WILLIAM A. FOWLER

INSTITUTE PROFESSOR OF PHYSICS

CALIFORNIA INSTITUTE OF TECHNOLOGY

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

MARCH 4, 1982

Mr. Chairman and Members of the committee,

I welcome this opportunity to testify at these hearings on a matter which has been a concern of mine throughout my professional career as an experimental nuclear physicist for the first 25 years and a theoretical astrophysicist for the last 15 years. That matter is instrumentation in university research laboratories. Almost exactly three years ago the late Philip Handler, then President of the National Academy of Sciences, testified before this Subcommittee on March 6, 1979. He began:

> "First, the matter of instrumentation. As you know, from 1967 to 1976 basic research was insufficiently funded to adequately support the enterprise already in being. During that time we used up much of our capital. Available funds were stretched as far as possible, used largely to pay salaries and consumable supplies while instrumentation requirements languished."

He concluded his remarks on instrumentation with:

> "Science is paced by ideas and instrumentation; it is wasteful and unwise to fail to provide adequate instrumentation if it is our society's intention that our scientific cadre shall be as productive as possible."

I can say it no better, but perhaps you will permit me to present my views on a problem which is now even more critical than when Philip Handler spoke three years ago. You are not going to hear from me a litany of what science can do for the general welfare, for the economy, and for the National defense. That has been well stated by many more persuasive than myself. I speak of the critical instrumentation situation in university research laboratories. First, I emphasize that I am presenting my personal views. It is true that as Chairman of the

Office of Physical Sciences in the National Research Council I am organizing a Work Shop on Instrumentation Needs of University Research Laboratories to be held March 12 and 13. Participants will come from government agencies and corporate research laboratories as well as from university research laboratories. I hope it will be the beginning of an effective and successful effort to get the instrumentation problem off dead center after a decade of failure. One thing I do know. The NRC is not going to sponsor another study of the instrumentation problem. Every agency representative I have talked to in Washington assures me the problem is recognized. What is needed are new ideas for a solution and that isn't going to be easy. But the workshop is still to be held and so I speak for myself.

Three studies of the instrumentation problem serve as background for my testimony. They are:

(1) The NSF/NAS Survey of Research Equipment Needs in Ten Academic Disciplines (February 1972). As a member of the National Science Board at that time I enthusiastically supported the request for this study by the NAS to the NSF and I was convinced that the bottom line of the Survey was realistic. That bottom line was:

> "The magnitude of the need is easily abstracted. It is large--i.e., well over $200 million in spite of the exclusion from the survey of equipment requiring additional staff."

The Survey was never published as an official NSF document. Nevertheless, NSF staff members have remained aware of the problem and have done much in their power to attempt to alleviate the problem over the past decade. I endorse NSF policies to date and their hopes for the future. In a recent talk to the Cosmos Club, John Slaughter, Director of the NSF said: "We must also address the increasing deterioration and obsolescence of research equipment and instrumentation at universities. Meeting the most pressing of these needs puts additional pressure on our available funds for research."

(2) The Scientific Instrumentation Needs of Research Universities, a report to the NSF by the Association of American Universities, June 1980.

(3) The Nation's Deteriorating University Research Facilities, a report prepared for the Committee on Science and Research of the AAU, July 1981.

These AAU reports convince me that the instrumentation problem is still with us and that unless it is cured, scientific research in the United States is in for trouble. In my book these two AAU reports are excellent in data base, analysis and presentation.

In addition, an Interagency Instrumentation Study chaired by Dr. Donald Langenberg, Deputy Director of the NSF, worked the problem. You have just heard from Dr. Langenberg about the plan for a special

multi-year government-wide initiative which was developed by the Interagency Study.

The two AAU reports should be available to this Subcommittee, so let me emphasize once again that I have chosen to present my own views. My qualifications for doing this are simply stated. In the last five years I have visited 37 university or college campuses in the United States to give 86 public lectures, colloquia and seminars, while in the same period visiting 5 national laboratories or observatories to give 9 talks, and 6 foreign universities to give 12 talks. Those visits lasted from two to five days which gave me the opportunity to inspect laboratories and to talk with undergraduates, graduate students, post-doctoral fellows, faculty and sundry department chairmen, deans, provosts and college presidents.

What did I learn? Certain laboratories on certain campuses were well instrumented and adequately equipped but the majority were not. Philip Handler was right. In spite of decreased funding in constant dollars, faculty salaries were still increased for merit and for inflation, and every effort was made to provide new positions for young faculty members, while graduate students and post-doctoral fellows were not denied opportunities to work in the laboratory or in the observatory. In my heart I cannot quarrel with that--people come first. At the same time, costs of operating and maintaining often obsolete equipment markedly increased. The end result was that funds for new instrumentation were frequently squeezed out of laboratory budgets.

What has been the result? There is the well-documented growing trend for experimental researchers to leave university laboratories for employment in industrial laboratories. This is usually attributed to the fact that higher salaries are paid in industry than in the universities. This is only partly true. One of the strongest motivations arises from the fact that industrial laboratories are more often than not better equipped and that industry allocates a high proportion of its research budget to new instrumentation relative to salaries and number of personnel.

Let's go beyond university faculty to the graduate students and post-doctoral fellows who do much of the work. In the training of experimental graduate students, we can no longer expect them to spend the increasingly lengthy periods needed to obtain a graduate degree working under the handicap of obsolete instrumentation. The same can be said when they go on to post-doctoral fellowships. Experimental graduate students and post-doctoral fellows must, of course, play a role in constructing the equipment they use. But they must be provided an adequate base in instrumentation already available and adequate support in designing and carrying out modifications or in building entirely new instruments necessary for the solution of their particular problems.

There is a melancholy aspect of the graduate student situation. It is again another well-documented trend, at least in the physical sciences, for graduate students to choose doctoral research in theory rather than in experiment. There are many reasons for this. Work in theory yields an enormous intellectual satisfaction. The deep need to

experiment can be satisfied by computer simulation. But that is not all. Why grub away in the laboratory for four or five or more years to obtain the Ph.D. degree wrestling with vacuum plumbing that leaks, laser beams too weak to do the job, mirrors that need repolishing, accelerators unable to produce high-current, high-resolution beams, travel arrangements to go to SLAC or Fermilab when the wife is working and the kid is too young for nursery school, and your doctoral supervisor can provide no funds even to buy the material to build the instrument you have designed and know must be built or purchased to do your thesis properly? Why not do theory instead? Let there be no misunderstanding here. Of course we need first-rate theorists--but we also need first-rate experimentalists.

What does it matter? Let's turn again to the old question--if things are so bad in American science, why do we continue to dominate Nobel Prize Awards? In my mind the answer is simple; American science has developed a research system that cannot be destroyed overnight and whose fruits will last for some time after the system itself has been destroyed, God forbid. What do I mean? We have a wonderfully balanced system of research productivity in university laboratories, in national laboratories, and in corporate laboratories. The competitive balance is important--each type of laboratory is unique and essential--but one key point must not be forgotten. The national and corporate laboratories employ and depend upon the graduate product of the university laboratories.

What are we doing in denying adequate instrumentation to our university research laboratories? The eventual long-term result is clear--no more experimental research in our universities and colleges. I raise the usual specter. We will wind up just like the Soviet Union. Their universities have few graduate research laboratories. A graduate student does his class work in the university and then goes to do his doctoral research in one of the many research institutes in the Soviet Union. There he can sometimes do very well indeed, but only in fields considered important by higher authority.

This has led the Soviets to too much central planning in science as in other matters. When I played high school football I got a big kick out of the story about the coach who was great for planning ahead. Before a game against a superior squad he told his team: "If you receive, run three plays and punt." Well, the team received all right, ran three plays down to the one-yard line and punted the ball over the bleachers. The Soviets ought to read our sports pages or maybe even Robert Burns. He was right!

Let's get back to the United States. In my mind the situation is painfully clear. Either we provide adequate instrumentation for university research laboratories or we lose one essential component in the American way of doing scientific research.

What is needed? It is not possible here to give an exhaustive list of instruments used in astronomy, physics, and chemistry. A partial list would include such instruments as:

-- advanced astronomical detectors and spectrometers
-- nuclear magnetic resonance spectrometers
-- chromatrographs, gas andliquid
-- mass spectrometers of various types
-- small accelerators of various types
-- cryogenic equipment for work in superconductivity
-- electron microscopes
-- electron microprobes
-- lasers
-- mini and micro computers
-- mossbauer spectrometers
-- ultrahigh vacuum systems

This brings me to what to do about the problem--again I emphasize these are my personal views. First of all, I urge this Subcommittee to support the NSF thrust in FY 1983 to address the problem through the research programs for each scientific discipline. The FY 1983 budget will provide a total of 95.3 million dollars for scientific equipment, an increase of 11.5 per cent over the FY 1982 current plan. This allocation of 95.3 million dollars is 8.9 per cent of the total NSF budget of 1073 million dollars and 9.7 per cent of that allocated for the conduct of basic research.

The provision of 95.3 million dollars for scientific equipment in FY 1983 through the various NSF research programs will help see us through the current period of financial stringency in the U.S. economy. Eventually, and the sooner the better, there must be an add-on to the budgets of all agencies supporting scientific research in the form of dedicated instrumentation funds.

It is my understanding that the DoD FY 1983 budget includes 30 million dollars in this form to meet the instrumentation needs of unclassified programs in basic research in universities and colleges supported by the DoD. That is a modest start in the right direction. But if DoD-supported laboratories need such dedicated funds above and beyond program funds in order to bring their instrumentation up to par, then so do laboratories supported by the NSF and other agencies.

Let me emphasize that dedicated instrumentation funds must represent an add-on to ongoing program needs. The need was critical in 1972 when a minimum of 200 million dollars was documented as the required add-on. During the last decade, this figure has increased to at least 1 billion dollars because of inflation, continuing obsolescence and increased complexity and cost of instrumentation. Dedicated instrumentation funds of 200 million dollars per year for five years would help considerably.

It is my conviction that these funds must be managed quite independently of current programs. Priorities must be established across disciplines. Competition must be open to obtain awards large enough to bring a given laboratory up to par. Losers the first time around can come back in subsequent years. Perhaps matching funds should be required, but on a graduated scale favoring the smaller colleges. Perhaps younger investigators should be favored. Don't listen to me about details. Given the opportunity, agency management

in cooperation with university faculty and administrators, and with helpful advice from corporate research management, can create a fair and equitable management policy which will restore the vitality and productiveness of our university research laboratories.

In the meantime, there is no point to counting one's chickens before they hatch. That brings me back to the Workshop on Instrumentation Needs of University Research Laboratories which I will chair next week. I am hoping that the workshop will be a start toward the development of mechanisms whereby the universities and the agencies with the counsel of the corporate sector can take a good hard look at their management policies in the limited areas of astronomy, physics, and chemistry. Given the economic facts of life, is too much going into payroll and operating costs and too little into new instrumentation? How much additional help can be expected from the corporate sector in view of new tax incentives? Where are matching funds to come from? Is debt financing a partial answer? We shall see.

What is the growing tendency for research faculty and their students to form users' groups and spend extended periods at regional or national laboratories doing to university life? How many disciplines besides high energy physics, space science, and big telescope astronomy must go this way? How are you going to keep them down on the farm after they have been out to SLAC? Let's study the problem and not let it be solved by default.

Let me conclude. The scientific community in universities realizes that the instrumentation problem will not go away. There are indications that the community is considering draconian measures--for example, debt financing, which will involve universities in risk management and uncertain future commitments. These measures may lead to a solution in the very short term. The critical phase lies down the road. Everyone, including this committee, must look hard and long down that road.

Thank you.

TESTIMONY BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
MARCH 4, 1982

Mr. Chairman:

My name is Robert Scott and I am Director of the Office of Financial Systems at Harvard University. In this position, I am responsible for the majority of our financial operations, including both research administration and capital financing.

Scientific research is critically important to the success of American technological and economic development and to assuring a strong, competitive position for American industry. High quality scientific research depends in large measure on the production of intellectual capital and trained men and women within the nation's universities. These processes, which cannot take place without adequate, modern facilities, are now constrained by an aging physical plant. I welcome your invitation to testify before the Subcommittee today on this important matter. I would like to use this opportunity to review with you our analysis, to describe some of the approaches to solving this problem which we have taken or are considering, and to suggest actions which Congress and the Executive Branch might take to assist universities in this very important area.

Stated in its simplest terms, universities attempting today to provide adequate scientific facilities face a problem of capitalization--specifically, a problem of lack of capitalization. Traditional methods of university management and financing have not provided significant levels of internal investment capital or risk capital to finance the

construction of facilities, to furnish those facilities with the necessary equipment, or to provide adequate seed funds to support ventures into potentially productive fields of research. This situation, which pervades higher education, is particularly pronounced with regard to scientific research since these fields have become quite capital intensive, since the cost for the necessary construction is particularly high, and since the early availability of the latest equipment is particularly important.

These issues are compounded by the fact that universities must work to address the capitalization problem during a period of great financial change for higher education. Since the mid-1960's, universities have faced continuously more complex and intractable financial problems and have needed to make increasingly difficult financial decisions that balance competing demands for limited resources. The decade of the 1980's does not promise to be one of expansion for higher education in general and yet it is during this decade that we must find an acceptable way to address the problems posed by the need to replace obsolete laboratory equipment.

Universities do not face the same financial incentives for investment in plant as do profit-making organizations. In part because universities are not tax-paying entities, they have tended to develop capital and pricing structures which do not accurately and fully reflect the costs of facilities and equipment. Capital costs have typically been met by private contributors, state legislatures, or the federal government. In general, annual university operating budgets have met only a very small fraction of the true costs of the facilities consumed during the period covered by those budgets. Particularly in the case of research facilities, where change has been particularly rapid during the past three decades, a large fraction of the capital support has been provided--directly or indirectly--by the federal government. Much of the excellence of American science is the result of this forward-thinking investment.

Universities today must plan for the development of their physical plant under two opposing constraints. On the one hand, the need for investment in scientific facilities is greater than it has ever been in the past. The rate of change within the fields of science which we all seek to support is increasing and that rapid change requires that laboratory renovation and re-equipping occur with considerable and increasing frequency. The simple fact is that laboratories need to be renovated frequently if modern science is to be conducted effectively, efficiently, and safely.

On the other hand, we face these needs during a time when federal support for equipment and other capital programs has decreased. Much of the equipment provided during the period of great expansion in federal support of university research between the mid-forties and the mid-sixties has been fully depreciated and is rapidly becoming obsolete. Increasingly, universities are making do with facilities that are not adequate or which limit the effectiveness and efficiency with which scientific research is conducted. All too often it is impossible to undertake new fields of scientific inquiry without new equipment. More frequently each year, the lack of adequate facilities compels universities to compromise or to forgo opportunities to move into areas in which they could make significant and unique contributions to the advancement of knowledge.

The growing need universities face for investment in research facilities and the decreasing level of real support for research provided by the federal government are combining to cause a significant problem. I know that this description will hardly be a surprise to you. However, I believe it worth restating in these terms because a number of the potential solutions to the problem we jointly face may be suggested by comparisons between the methods of management within universities and the

relatively more successful efforts of industry to provide capital funds for their programs.

Universities are very grateful for--as well as dependent on--the direct support of their capital needs for research equipment which has been provided by the federal government. I urge you to do all that is possible to continue and increase this level of support for its value is hard to overestimate. However, in addition to providing direct financial support, there are a number of other actions which Congress and various agencies in the Executive Board could take to make it easier for universities to solve their own problems and, equally important, to encourage others to invest in the development of university research.

The traditional solution adopted by private universities to the need to provide capital facilities for research has been to seek support for the required facilities either from the sponsors of the related research in the federal government or industry or from general donors. When successful, this approach covers in advance the entire capital cost and resolves the capital problem. However, this approach is a particularly expensive to those providing support for it neither distributes the costs of the facilities provided across the several years during which they will be used nor assigns a fair share of the cost to the many programs which will benefit from those facilities. This practice has contributed to the decline in the level of equipment available since research sponsors have resisted such practices--which amount to implicit cross-subsidies--as funds have become scarcer.

To the extent that federal support of capital costs is still available, the majority of that support is provided as a part of the budgets of annual grants. Since the

expenses covered by such budgets are used largely to pay annual costs such as salaries, travel, supplies, and indirect costs, a decision to acquire capital equipment is particularly hard since it requires the use of annual funds to incur up front a cost which will benefit not only the current budget period, but also other periods to come in the future. When annual funds are used for capital purposes and when the equipment provided will be used over a period of years, then a capital expenditure made by one grant will assist related grants which are conducted in subsequent years, just as the grant making the capital expenditure will in all probability benefit from capital expenditures made by related grants in previous years. For example, if a grant budget is to provide on a current basis the entire capital cost for a piece of equipment that will last for seven years and that will be used equally by three research programs, then the charge to that grant will be more than twenty times larger than it would be if the grant covered only the cost related to its share of the first year of the useful life of that piece of that item of equipment.

This financing method has been the method of choice for many years. There are several reasons for this state of affairs, not the least of which are that it has been possible and conservative. However, consider for a moment where private industry or individual families would be today if each needed to provide capital costs without charging those costs to future annual budgets. Far less capital investment would have occurred or would be possible today.

An alternative way for universities to manage their capital affairs is to follow the industrial analog and to consider these costs as investments which should be financed and then written off over a period of time. This approach has much to recommend it. First, costs are assigned to the specific programs which they benefit

and individual programs do not subsidize each other. Second, using this approach, universities will be able to plan far more effectively for their equipment needs since they will be able to acquire equipment on a well-thought-out schedule and without particular regard to the level of support which happens to be available in the very short term.

Such an approach is not without risk. If a university is to acquire equipment on a capitalized basis, it must make a commitment to bear the cost in future years. A university may not know precisely and in advance what research equipment it will need for future research projects nor will it know what level of support will be available in annual budgets to support the costs of equipment purchased for the future. This, of course, is precisely the risk which universities now take when they construct or renovate buildings. A balanced approach is surely possible under which universities ask their annual budgets to cover less of the cost of equipment purchases and to cover, instead, a reasonable share of the cost of that equipment: a share that reflects the likely lifetime of that equipment and its utility to other programs.

In short, I believe that much can be done to address this problem if universities are able to plan and acquire the capital research facilities which they need through internal financing, through conventional or tax-exempt debt, or through leases. At Harvard, we have considered a number of these alternatives and have developed specific plans in several areas. A number of universities have already moved in this direction. There are, however, a number of obstacles which we face. Although I realize that a number of executive agencies and congressional committees would need to be involved, I would like to suggest for your consideration several changes to laws and regulations which, if made, would make these new approaches far more easy to achieve.

1. Any capitalization brings with it a real or imputed interest cost. Interest rates are now at relatively high levels yet federal regulations specifically prohibit the recovery from federally sponsored research projects of those projects' shares of interest costs associated with the capital facilities they use. The Office of Management and Budget has proposed a change to the regulations in this area which are contained in OMB Circular A-21. This change would permit inclusion of relevant interest costs in the costs of research beginning on July 1, 1982. Formal adoption of this change is critically important for it will remove the most significant barrier which has faced those trying to develop imaginative and constructive capital financing systems. In addition, removal of the barrier which now exists will eliminate a number of economic disincentives. For example, rental space is frequently used instead of purchased space, even though more expensive, for the simple reason that its costs are fully recognized in the relevant federal regulations while the costs of purchased space are only partially recognized.

2. Universities are tax-exempt organizations. As a result, the equipment which they purchase carries no investment tax credit regardless of whether it is owned by the university itself or owned by a third party and leased to the university. This is a particularly unfortunate situation since it reduces the incentives for universities to purchase equipment. In fact, since it is in universities that much of the intellectual capital of the nation's science is generated, the national government should provide the <u>greatest</u> incentives for capital investment in these institutions. The investment tax credit should be made available for equipment used in universities. Such a change will reduce the cost of research equipment acquired by universities by permitting universities to benefit from the

tax incentives which the nation has determined should apply to the purchase of assets designed to improve productivity.

3. All possible action should be taken to improve the incentives for private individuals and corporations to make capital equipment and facilities available to universities. For example, decreasing the limits which now exist on charitable deductions or allowing donors to utilize investment tax or depreciation credits on equipment which they donate could each make significant improvements to the equipment environment in universities. Also, if limits which exist on research and development tax credits for research performed at universities under corporate sponsorship were removed, then industry would be encouraged to support university programs more fully. In general, I believe that economic efficiency will be very greatly improved if business and industry are permitted--or, more important, encouraged--by the tax code to support the training of scientists and engineers and to provide for the development of intellectual capital through the support of universities.

I welcome this opportunity to discuss this important problem area with the Subcommittee. At Harvard, we realize that our scientific research activities must be based on modern, well-designed, and well-equipped laboratories. We recognize that the construction and equipping of those laboratories is our responsibility and we are developing the financial programs which are required to assure success. We, along with other colleges and universities, appreciate sincerely the direct assistance which the federal government has provided in the past and can provide in the future. However, it is equally important that everything possible be done to encourage others to invest in university research and to permit universities themselves to address this

issue and to take relevant action, not in a climate of undue disadvantage but rather with every positive incentive.

I will, of course, be glad to answer any questions you may have. Thank you.

STATEMENT OF LEWIS M. BRANSCOMB
CHAIRMAN, NATIONAL SCIENCE BOARD
SUBMITTED TO THE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES
MARCH 4, 1982

My name is Lewis M. Branscomb. I am Chairman of the National Science Board, and am submitting this statement in that capacity. I also am Vice President and Chief Scientist of the IBM Corporation.

Dr. Langenberg discussed the importance of the industrial sector. I want to make some general observations on research instrumentation, and will emphasize the importance of Government policies that can encourage the private sector to participate more effectively in upgrading scientific equipment in the universities.

But, first, I want to make a brief observation on the other question on today's agenda--the participation of women and minorities in scientific and engineering careers. The National Science Board places a very high value on excellence in science. All our experience shows that discoveries cannot be planned, that trying hard is not a substitute for talent, that natural ability, motivation, and opportunity are the recipe for scientific excellence. We equally firmly believe that natural ability in mathematics and science is distributed randomly throughout all elements of our population. Unhappily, some of our youth, especially young women and minorities, are often discouraged from pursuing scientific careers. And opportunity for those careers does not always follow ability and motivation alone.

The consequence of these facts is that the excellence of our science inevitably suffers if we fail to give every rare talent the opportunity to prove itself. Equal opportunity is not counter to a focus on excellence; it is indispensable to it. Thus, it is appropriate that all the programs of the Foundation be conducted with this fact in mind. Quite apart from the matter of fairness, our country simply does not have enough bright, scientifically inclined youngsters for us to afford to deprive a good education, high motivation, and career opportunity to any of our citizens.

Let me now turn to the question of instrumentation. This issue is more important than the contribution to research productivity that modern instrumentation can provide. The fact is that the tools of science and the tools of productivity are linked by the processes of discovery and innovation, each contributing to the other. Leading edge scientific instrumentation is an essential link in the evolution of new scientific ideas to exploitation of these ideas in the Nation's technology. The National Science Board addressed this point in our policy statement of March 1981, which noted that keeping university equipment at the cutting edge sparks both innovation and productivity improvements in American industry broadly.

Thus, the policy of the Board goes beyond balancing the Federal investment between facilities and talent for research. We seek to keep vital the roots of invention of new instrumentation for science, the rapid development of these ideas by private

companies, large and small, and the evolution of the researcher's tools into the design and production tools of industry.

To this end a close collaboration among our university and industrial laboratories is essential. The Economic Recovery Tax Act of 1981 contains two provisions intended to encourage industry to share its instrumentation and knowledge with universities to their mutual benefit.

First, Section 221 of the Act provides a 25 percent tax credit for incremental R&D expenses. The credit equals 25 percent of the amount by which qualified R&D expenses during a year exceed the average of the previous three years. Qualified R&D expenses for in-house research include the wages of researchers and direct support personnel, the cost of supplies, and payments for the lease of equipment. Thus overhead and capital costs are not eligible for the credit (although the company's capital equipment costs may qualify for the investment tax credit). Qualified research expenses for research contracted out are 65 percent of the contract cost, a percentage designed to approximate the ratio of wages, supplies, and leased equipment to the total research cost.

This provision could and should be used by private firms to collaborate with colleges and universities and improve their instrumentation. For example, if a firm sponsored a university research project involving the purchase of a centrifuge, the cost of the centrifuge would be fully deductible as a research expense to the firm. Furthermore, 65 percent of the centrifuge's

cost would be included as "qualified research" and would count in computing the amount of incremental research eligible for the 25 percent credit to the firm. Thus, if the centrifuge were part of the firm's incremental research and the firm were in the 46 percent tax bracket, the firm would pay for only 38 cents out of each dollar of the cost of the acquisition of the centrifuge by the university. If the same research were conducted in-house at the same gross expense, the centrifuge would cost the company a net after tax cost of 54 cents out of each dollar, minus the tax benefits of depreciation.

Unfortunately, Section 221 has administrative and substantive ambiguities that may limit its value in encouraging firms to increase R&D expenditures, including those expenditures that improve instrumentation at universities. The Treasury is now drafting regulations to reduce uncertainty. The issuance of proposed regulations for Section 221 deserves and is receiving a high priority, and the proposed regulations should be published soon.

Section 222 can be even more valuable in encouraging firms to assist in updating equipment at colleges and universities. After the passage of Section 222, contributions of equipment to universities entitle the firm to a much larger tax deduction if certain conditions are met. For example, if a firm donates a new centrifuge that costs $100 to make and sells for over $300, the tax deduction would be only $100 under the old law but $200 under Section 222. Firms can be expected to significantly increase donations of scientific equipment to colleges and universities

once they gain familiarity with the favorable provisions of the new law.

In order for a firm to receive the increased donation, the gift must be new equipment that is constructed by the firm and given without strings attached to an institution of higher education. The firm and the institution must have a written agreement that the equipment will be used in the U.S. for research in the "physical or biological sciences." These conditions also involve some uncertainties that must also be resolved by Treasury regulations. For example, the very term "physical or biological sciences" must be interpreted or extended to include mathematical and engineering sciences at a minimum. The issuance of regulations now being developed that reduce or eliminate uncertainty and guide firms in the proper use of Section 222 will be beneficial to American science and technology.

Many firms are studying ways to use these provisions to improve and update the scientific instrumentation used by our country's colleges and universities, but the extent of their effect is still unknown.

The Foundation should and will seek to encourage private companies to expand their participation in university research, and these provisions will surely help. But we cannot realistically expect the obsolescence problem described by Dr. Langenberg to be solved in this way. We must also encourage the universities to share expensive facilities, to avoid the temptation to underinvest in equipment as a fraction of project cost, and to find

innovative ways to capitalize new equipment acquisition with non-Federal funds.

I am pleased to have had the opportunity to present these views.

STATEMENT OF

DR. DONALD N. LANGENBERG

DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

MARCH 4, 1982

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE,

AS DR. SLAUGHTER MENTIONED IN HIS TESTIMONY LAST WEEK, WHILE ASSESSING OUR PRIORITIES AND NEEDS IN THE PREPARATION OF THE FY 1983 BUDGET REQUEST, WE TOOK A CLOSE LOOK AT RESEARCH INSTRUMENTATION AND FACILITIES NEEDS RELATIVE TO OTHER RESEARCH OPPORTUNITIES.

AS THE MEMBERS OF THIS COMMITTEE KNOW, OVER THE LAST FEW YEARS THE FOUNDATION HAS PLACED A VERY HIGH PRIORITY ON UPGRADING THE SCIENTIFIC AND ENGINEERING INSTRUMENTATION AVAILABLE IN THE NATION'S COLLEGES AND UNIVERSITIES FOR CONDUCTING FOREFRONT RESEARCH IN A VARIETY OF DISCIPLINES. THIS YEAR IS NO EXCEPTION. I WOULD LIKE TO TAKE A FEW MOMENTS TO CHARACTERIZE THE GENERAL NATURE OF THE PROBLEM AND DESCRIBE FOR YOU WHAT THE ADMINISTRATION IS PROPOSING IN THE FOUNDATION'S FY 1983 BUDGET.

There is an emerging consensus in universities, the Federal government and private industry that there is a critical and growing need to replace obsolete and worn-out research apparatus and laboratory facilities in the Nation's research universities.

Although its precise dimensions are not known, there is strong, qualitative evidence that the problem is pervasive and large in scope. A rough, but reasonable, estimate of the lower level of the deficit is $1.0 billion. Upper boundaries of the problem have been placed in the $3.0-$4.0 billion range.

If the general assessment of the scope and nature of the problem is a correct one, and we believe that it is, it means that the productivity and efficiency of the Nation's academic research enterprise has already declined and will continue to decline. Most of modern science and engineering research is instrument-dependent. Capital investment in advanced instrumentation and facilities is necessary if we are to maintain our national position at the forefront of a wide variety of disciplines and to obtain maximum productivity in the future from our investment in research.

Currently, the Foundation is exploring the development of a system of indicators on the status of university research laboratories and equipment to give us a better picture of the scope of the problem. Preliminary data obtained in the fall of 1981 in a sample of 38 institutions suggest that about half of all equipment

HOLDINGS WERE ACQUIRED 6-10 YEARS AGO AND THAT SHARED USE OF INSTRUMENTS AMONG RESEARCHERS AND DEPARTMENTS IS VERY COMMON.

EVEN THOUGH CONSIDERABLE WORK REMAINS TO BE DONE TO DEVELOP BETTER QUANTITATIVE INFORMATION, SOME IMMEDIATE ACTION CAN BE TAKEN. I WOULD LIKE TO DISCUSS SEVERAL THINGS THAT HAVE BEEN DONE IN THE PAST YEAR, AND COMMENT ON HOW NSF'S CURRENT BUDGET REQUEST ADDRESSES THE SITUATION.

EFFORTS TO UPGRADE OUR RESEARCH "HARDWARE" ARE CLEARLY NECESSARY; YET, THE NATION FACES ECONOMIC PROBLEMS AND BUDGETARY CONSTRAINTS. ANY SOLUTION MUST ENCOMPASS NOT ONLY THE FOUNDATION, BUT OTHER FEDERAL AGENCIES, ACADEMIC INSTITUTIONS THEMSELVES, STATE GOVERNMENTS AND INDUSTRY.

LAST AUGUST, WITH THE SUPPORT OF THE DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY, THE FOUNDATION CONVENED AN INTERAGENCY WORKING GROUP ON UNIVERSITY RESEARCH INSTRUMENTATION TO BEGIN REVIEWING THE NATURE AND EXTENT OF THE PROBLEM AND TO EXPLORE SEVERAL SCHEMES FOR A POSSIBLE FEDERAL RESPONSE TO IT. REPRESENTATIVES OUTSIDE NSF CAME FROM THE DEPARTMENT OF AGRICULTURE, DEPARTMENT OF DEFENSE, DEPARTMENT OF ENERGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, AND THE NATIONAL INSTITUTES OF HEALTH.

THE WORKING GROUP CONCLUDED THAT INADEQUATE UNIVERSITY RESEARCH INSTRUMENTATION WAS INDEED A PERVASIVE AND ENDEMIC PROBLEM, AND THAT THE NATION WOULD BENEFIT FROM ITS ALLEVIATION.

BECAUSE OF THE DIVERSITY OF MISSION RESPONSIBILITIES, AN APPROACH INVOLVING INTERAGENCY COORDINATION RATHER THAN A SINGLE INTEGRATED PROGRAM WAS THOUGHT TO BE PREFERABLE. SUCH A STRATEGY FACILITATES MATCHING INDIVIDUAL AGENCY PRIORITIES, ASSESSING THE RELATION TO OTHER RESEARCH REQUIRMENTS, AND ENABLING A BETTER RESPONSE TO SPECIAL NEEDS OF DIFFERENT SCIENTIFIC AREAS.

FOLLOWING THIS PLAN, IN FY 1983:

- THE DEPARTMENT OF DEFENSE IS PROPOSING A $30 MILLION INITIATIVE TO BUILD THE UNIVERSITY RESEARCH BASE FOR DISCIPLINES RELATED TO ITS SCIENTIFIC PROGRAMS;

- NASA IS HAVING ITS PROGRAM OFFICERS GIVE SPECIAL ATTENTION TO PROJECT-RELATED INSTRUMENTATION REQUESTS;

- NIH PLANS TO INCREASE ITS CURRENT INSTRUMENTATION PROGRAMS SLIGHTLY;

- THE DEPARTMENT OF ENERGY PLANS TO INSTRUCT ITS PROGRAM OFFICERS TO PROTECT BUDGETS FOR INSTRUMENTATION IN ITS RESEARCH AWARDS;

- NSF RESEARCH PROGRAMS ARE INCREASING THEIR SUPPORT FOR MAJOR EQUIPMENT AND OTHER INSTRUMENTATION BY 11.5 PERCENT OVER FY 1982 TO A TOTAL OF $95.3 MILLION; AND

- The Interagency Working Group will continue to monitor, coordinate and heighten awareness of the problem.

Within the NSF total, each scientific area in the Foundation is responding to the needs of its discipline. Overall increases in equipment and instrumentation support relative to FY 1982 range from 4.8 percent for the U.S. Antarctic Program to 23.5 percent for Engineering.

Some programs have increased their support to investigators on their research grants; some are providing instrumentation for shared use; some provide research instrumentation and facilities that are too specialized and expensive to warrant duplication.

Within the Mathematical and Physical Science Activity, for example, previous emphasis on experimental computer research will continue the multi-user regional instrumentation facility.

The physics program will provide support for constructing a Cooler Ring at the Indiana University Cyclotron and for improving the detector and storage ring at the Cornell Electron Storage Ring.

In the Biological, Behavioral and Social Science activity particular attention is being given to upgrading instrumentation at marine biological stations, strengthening archeometric dating facilities, and in general providing adequate instrumentation in research project awards.

THE ENGINEERING PROGRAM PLANS TO SUPPORT THE INITIAL PHASE OF A FLUIDIZED BED RESEARCH FACILITY.

AS PART OF THE THRUST IN EARTH SCIENCES, IN THE ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES ACTIVITY, SUPPORT OF EQUIPMENT IS BEING ENHANCED ON INDIVIDUAL GRANTS FOR GEOCHEMICAL AND GEOPHYSICAL RESEARCH.

FUNDING FOR RESEARCH INSTRUMENTATION FOR FACULTY AT TWO-AND FOUR-YEAR COLLEGES WILL CONTINUE IN FY 1983. THIS PROGRAM APPEARS TO HAVE BEEN EXTREMELY SUCCESSFUL IN SUPPORTING SMALL RESEARCH EQUIPMENT ACQUISITION AT THESE INSTITUTIONS, THUS UPGRADING SIGNIFICANTLY THE RESEARCH CAPABILITIES OF THEIR FACULTIES. INSTEAD OF PROVIDING A SEPARATELY IDENTIFIED BUDGET LINE FOR THE PROGRAM, SUPPORT WILL BE PROVIDED BY THE RELEVANT RESEARCH DIRECTORATES IN ORDER TO MAINTAIN A CLOSE COUPLING TO THE SCIENCE DISCIPLINES.

IN CONCLUSION, WHILE THE FOREGOING ACTIVITIES WILL CERTAINLY NOT ELIMINATE THE NEED FOR MAJOR RENOVATION OF ADVANCED SCIENTIFIC AND ENGINEERING INSTRUMENTATION THEY DO REPRESENT A REALISTIC AND MEANINGFUL APPROACH AT A TIME WHEN OVERALL ECONOMIC RECOVERY IS A MAJOR NATIONAL CONCERN. WHAT HAS BEEN DONE BY THE FOUNDATION IN FY 1982, AND IS PROPOSED FOR FY 1983, CALLS ATTENTION TO THE NEED FOR CONTINUING EFFORT IN THIS AREA; PROVIDES FOR A BALANCE ACROSS AREAS OF SCIENCE; MEETS THE MOST CRITICAL CURRENT RESEARCH NEEDS WITHIN A

CONSTRAINED BUDGET, AND ALLOWS FOR THE EXPLORATION OF NEW WAYS OF PROVIDING THE INSTRUMENTATION ESSENTIAL TO FULL UTILIZATION OF THE NATION'S SCIENTIFIC AND ENGINEERING MANPOWER POOL, E.G., STIMULATING INDUSTRY TO CONSIDER DONATING INSTRUMENTATION TO A UNIVERSITY IN COORDINATION WITH THE AWARD OF AN NSF GRANT.

I WOULD BE PLEASED TO ANSWER ANY QUESTIONS THAT YOU MAY HAVE.

NATIONAL SCIENCE FOUNDATION
BUDGET IN BRIEF
FY 1983
EXCERPT

RESEARCH INSTRUMENTATION AND LABORATORIES

Much research today is instrument-dependent and many advances can only be made through improvement of instrumentation. Investment in research instrumentation is an investment in the future growth and productivity of modern science and engineering.

There is growing recognition that, as a Nation, we may be underinvesting in state-of-the art instrumentation and associated facilities in academic institutions. Such investment is critical to the conduct of cutting-edge research and the overall advancement of the Nation's science and technology base. In the FY 1983 Budget Request, the Foundation is addressing this problem in multiple ways through the research programs for each discipline.

R&D EQUIPMENT AND INSTRUMENTATION
(Obligations in millions of dollars)

Program Activity	*Major Equipment**			*Other Equipment & Instrumentation***		
	Actual FY 1981	*Estimate FY 1982*	*Estimate FY 1983*	*Actual FY 1981*	*Estimate FY 1982*	*Estimate FY 1983*
Research and Related Activities:						
Mathematical and Physical Sciences	$3.7	$5.1	$7.2	$32.4	$33.9	$37.7
Engineering	.9	.6	1.3	5.3	6.2	7.1
Biological, Behavioral, and Social Sciences	.0	.0	.0	15.2	15.0	16.1
Astronomical, Atmospheric Earth and Ocean Sciences	2.1	2.1	1.7	17.5	17.2	19.1
Ocean Drilling Programs	.0	.0	.0	.0	.0	.0
U.S. Antarctic Program	.0	.0	.0	2.0	2.1	2.2
Scientific, Technological and International Affairs	.0	.0	.0	6.5	1.4	1.8
Minority Institution Science Improvement Program	.0	.0	.0	1.6	1.6	1.1
Program Development and Management	.0	.0	.0	.0	.0	.0
Subtotal, Research and Related Activities	6.7	7.8	10.2	80.5	77.4	85.1
Science and Engineering Education	.0	.0	.0	6.2	.3	.0
Special Foreign Currency	.0	.0	.0	.0	.0	.0
Total, NSF	$6.7	$7.8	$10.2	$86.7	$77.7	$85.1

* *Major Equipment*—Applies to a relatively limited number of specific items of specialized R&D equipment, such as accelerators, telescopes, research ships, aircraft, and the like.

** *Other Equipment and Instrumentation*—Includes R&D equipment other than those items specifically categorized as "Major Equipment". To qualify as equipment, an item must cost at least $300 and have a use-life of at least one year. Items in this category are treated as part of the cost of "Conduct of R&D".

This strategy facilitates an assessment of instrumentation needs relative to other research requirements and permits maximum flexibility, within the requested levels, for responding to the varying priorities and needs of different disciplines.

The FY 1983 Budget Request contains estimated obligations of $109.2 million for research facilities, instrumentation, and equipment. Within that total, major equipment and other instrumentation alone will equal $95.3 million or 11.5 percent over the FY 1982 Current Plan of $85.5 million.

SUMMARY—R&D FACILITIES, EQUIPMENT AND INSTRUMENTATION
(Obligations in millions of dollars)

	Actual FY 1981	Estimate FY 1982	Estimate FY 1983
Land, Buildings, and Fixed Equipment*	$8.0	$3.2	$13.9
Major Equipment	6.7	7.8	10.2
Other Equipment and Instrumentation	86.7	77.7	85.1
Total, NSF	$101.4	$88.7	$109.2

*Land, Buildings, and Fixed Equipment—Acquisition, construction, rehabilitation, addition to, or improvement of real property assets, such as land, buildings, or other structures, and fixed equipment. "Fixed equipment" means equipment that is part of the building, such as elevators, plumbing, lighting and heating systems, air conditioning systems, fire alarm systems, and the like.

There are opportunities here for other Federal R&D funding agencies to respond to instrumentation needs. And, indeed, the Foundation, with the support of the President's Science Adviser, organized and chaired the Interagency Working Group on University Research Instrumentation with representatives from the Department of Defense, the Department of Health and Human Services, the Department of Energy, the Department of Agriculture, and the National Aeronautics and Space Administration. This Working Group reviewed the nature of the problem and considered the Federal role and possible responses within the context of each agency's FY 1983 Budget Request.

In passing Section 222 of the Economic Recovery Tax Act of 1981 which permits an increased deduction for manufacturers who donate scientific research equipment to institutions of higher education, the Congress specifically recognized the need to upgrade the scientific equipment available to universities and to encourage an expansion of the corporate role in that effort. Similarly, State legislatures and local governments as well as university trustees, administrators and faculty might explore new, creative ways of financing the upgrading of such instrumentation and of giving it major priority in their budgetary deliberations.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D C 20550

nsf

OFFICE OF THE
DIRECTOR

February 12, 1982

To: Members of the NSB Planning and Policy Committee

From: Deputy Director

Subject: University Research Equipment Support Through Industrial Donations

The Chairman has asked the PPC to consider means by which the Foundation might interact with industry, particularly manufacturers of research instrumentation, to encourage industry to contribute to the solution of the university research instrumentation problem. This memorandum is intended to convey to PPC some thoughts developed from extensive discussions of the topic among Foundation staff. There is a wide range of possibilities for NSF, including:

1. No NSF action: This option simply allows the marketplace to work, with universities and industry pursuing their individual and mutual interests as they see fit, with no involvement of NSF.

2. NSF as hortator. The Director, the Chairman, Board members, and NSF staff might exhort industry to donate equipment or funds, via NSB resolution, speeches, testimony, etc. Exhortation might be accompanied by information on tax law incentives, on NSF grantees as possible recipients, on the magnitude and nature of the need, etc. Such information could be assembled in a brochure and disseminated to potential donors and recipients. This NSF role would be consistent with language in our 1983 Budget in Brief:

> "Overall, however, the Foundation's role in stimulating areas of industry/university research cooperation can be only a small, catalytic one. Major initiatives for exploring the full range of possible cooperative activities must come from the academic and industrial sectors themselves. Though their objectives and roles in the national research and development system are different, they are, at many points, interdependent. Thus, the opportunity to identify and explore common ground in areas ranging from educational quality and skilled personnel shortages to scientific and engineering research instrumentation and mutual basic and applied research interests presents one of the major challenges of the 1980's."

3. NSF as direct collaborator with donors: A possible mechanism for more direct involvement of NSF, developed by generalizing the SEE courseware program plan, is:

- o NSF invites any and all manufacturers and suppliers of equipment useful in university research to participate in a joint program.

- o Each industry participant agrees to donate equipment. A minimum donation may be required. A "catalog" file listing equipment is maintained by NSF, and made available to program officers and to proposers.

- o NSF accepts, reviews, and makes decisions on research proposals, including equipment, in its normal fashion. If an award is recommended and the project includes a scientifically justified equipment request, the NSF program officer either:

  (1) Recommends the award including NSF funds for equipment, or

  (2) Triggers instructions to the donor to transmit the requested equipment directly to the grantee, and recommends award without NSF funds for equipment.

  NSF does not act as distributor, nor does it take title to or possession of the equipment.

- o Donors are required to agree to minimum standard conditions, including a limitation on the use of NSF's name in PR without permission, and a commitment to donate automatically without involvement in the review process. We might allow donors to restrict donees broadly, e.g., to engineering departments.

- o NSF does not undertake judgment of the quality of the equipment, except very indirectly in the course of making an award decision. The primary role in selecting and judging equipment is left with the proposers and peer reviewers, as usual.

- o NSF explicitly disclaims any endorsement of the donors or their donations.

4. NSF as indirect collaborator with donors. Some similar mechanism for achieving the same effect might be developed and operated by another organization, e.g, NAS, AAAS, or professional societies, with encouragement and/or support by NSF. If one assumes that NSF's objective is to induce the creation of an active system which assures that donated equipment goes to support the highest quality research, it would be necessary for the third party organization to develop and use some form of peer review system. This would require staff and financial resources which NSF and, perhaps, other agencies would probably be called on to provide. It is however possible that the universities and industries themselves might be persuaded to provide this support.

Preliminary discussion in Executive Council has indicated support for pursuing Option 3. Inaction is unacceptable given the seriousness of the instrumentation problem and our repeated expressions of interest in cooperation with the private sector. Option 2 has the weakness of most exhortations to do good works; cheerleaders are nice, but they don't win football games. Nevertheless, this option probably represents something we should do in any event. Option 3 is fully within existing NSF authority; collaborative endeavors involving both NSF and industry are not without precedent. It couples equipment donations directly to judgments of scientific quality made by an existing and widely respected peer review system. Option 4 might be designed to achieve the same effect and has the possible advantage of putting some distance between the Foundation and the program. On the other hand, it would require the establishment of another quality assurance system possibly requiring support by the Foundation, or run the risk of weak coupling of donations with scientific quality.

Obviously much informal exploration of mechanisms for implementing Options 3 or 4 would be required before proceeding formally. This should include discussions within the directorates and with university and industry representatives. (Two opportunities for beginning such discussions are imminent, the NAS meeting on instrumentation scheduled for March 12-13, and the "Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy," March 8-12.)

The reader will detect in the above my personal conviction that we should proceed with exploration of Option 3. I urge the PPC to recommend and the Board to adopt a policy of direct and active cooperation with industry in this matter and to request that the Director undertake a staff study of how to do it.

Donald N. Langenberg

would be intolerable, were it not borne largely by public agencies in the expectation of benefits to society. Today, more than half of all basic research in the United States is done in universities and is supported overwhelmingly by the federal government.

This university-government collaboration has helped to maintain the United States in a position of technological leadership for over four decades, but we must remain alert to any symptoms of degenerative disease if we are to maintain that leadership in the face of continued challenge.

I appreciate the opportunity that has been afforded to me to discuss one such sympton: namely the declining state of research instrumentation in American universities. You have heard previous testimony concerning the circumstances that have led to the present problem and estimates of the accumulated need in dollars. Whether that need is $1 billion or $4 billion is not, I think, what should concern us here. It is unrealistic to suppose that either sum of money could be made available under present circumstances. What, then, can be done?

On March 12 and 13 of this year an ad hoc working group on scientific instrumentation assembled at the National Academy of Sciences to consider this problem. The group consisted of leaders of industrial R&D laboratories, representatives of various government agencies concerned with the problem, and university researchers. It was led by William A. Fowler, who has testified on this subject on the House side. The focus of the meeting was on instrumentation in the $50,000 to $1 million range in chemistry, physics, related areas of astronomy, and the life and earth sciences.

I was struck by the unanimity of the consensus that the problem of research instrumentation in universities seriously threatens the health of the

scientific enterprise in the United States -- in the short term by its direct impact on scientific research and in the long term by its effect on the training of scientists. The participants agreed that the problem was well documented and so spent the meeting discussing ways to ameliorate the problem within existing budgetary constraints. This Committee has a first draft of the report of that meeting, including the executive summary. Let me, then, if I may, comment on those aspects of the problem discussed during the NAS meeting that appear to me to be most serious. I will add a few words of caution about some of the proposed solutions, lest new problems be created in the act of solving the old.

1. Block Funding

I believe the most serious challenge is to provide equipment for new faculty and for established faculty who wish to undertake major changes in the direction of their research programs. Such changes are a measure of progress. It is inevitable that if we solve problems, the equipment designed to effect those solutions becomes obsolete. We must not cling to stale or outmoded research programs simply because we lack the resources to move on to areas of current concern. I believe the most straightforward way to address this problem is to provide block funding to institutions that can be used flexibly to provide instrumentation.

As a science administrator, however, I recognize the problem inherent in this approach. There is enormous pressure in the administration of flexible funds to provide help primarily to those who have difficulty in obtaining support from other sources. This often results in such funding being dissipated on second-rate researchers. There is therefore a need for safeguards, such as an annual peer review of the uses made of such block-

funding.

2. Debt Financing

There was much discussion of creative financing techniques during the NAS meeting. By this I refer to such approaches as overcoming the obstacles to capital acquisition presented by the grant system through leasing equipment from third parties. Anyone who has been living on a faculty salary these past few years has some gut feeling for debt financing, but it is an unfamiliar concept for University administrators. Universities must, however, be willing to use these techniques for the acquisition of major items of instrumentation. Such arrangements enable instrumentation to be financed either through direct-use charges against the grants or by inclusion in the indirect cost pool used in computing the overhead. This enables the institution to get equipment quickly. But no new money is created and the cost may ultimately appear somewhere else in the research program. A possible consequence of this type of financing will be to shift the instrumentation problem from major items of equipment to items of a few thousand dollars.

3. Central Facilities

It has been suggested that the problem of scientific instrumentation in the universities could be alleviated by greater reliance on centralized research facilities utilized by a number of institutions in a given geographical area. It should be noted that the concept of jointly used facilities is firmly established in fields of physics requiring instrumentation of very high cost, such as high-energy particle accelerators and synchrotron-light sources. When instrumentation of such high capital cost is involved, there is no alternative to centralized research facilities. The question, then, is whether this same principle should be extended to less

costly facilities. Here I would urge great caution. Almost by definition the frontiers of knowledge cannot be moved appreciably with standardized commercial instruments. On the contrary, fundamental advances in knowledge are made with one-of-a-kind instruments, although the support of many standard analytical instruments may be required. As regional instrumentation facilities are developed, there is a tendency to distort research objectives to fit the instruments available.

A second serious concern with increased reliance on central facilities has to do with the effect on training graduate students. An important aspect of that training has to do with the interaction between graduate students, particularly across disciplinary lines. Reliance on centralized facilities tends to limit the experience of the graduate student to people working in areas closely related to his own.

The NAS Workshop concluded with a meeting of an industrial caucus and a university caucus. The former was led by George Pake, Vice President for Research of the Xerox Corporation, which has invested a substantial part of its corporate resources in upgrading the Nation's technology base. I led the university caucus. My academic colleagues were impressed by the rational approach of their industrial colleagues in managing research and were open to seeking ways to promote better management of resources and to facilitate planning for a reasonable balance between manpower and capital acquisitions. We agreed that a series of regional tutorial workshops, held across the country, could do much to encourage the academic community to take an active role in solving this problem. These workshops would bring together on a local

scale industrial research leaders, university researchers, and scientists from federally funded laboratories. I hope that continued discussion among those three elements of the U.S. scientific enterprise can work to the mutual benefit of all three sectors in solving this fundamental problem.

The emphasis of the NAS Workshop was on seeking solutions within "existing budgetary constraints." Certainly we must make every effort to manage our resources efficiently. This is, however, only part of the problem. I have worked in both corporate and government laboratories. In my view, universities do not do all that bad a job of management. Without new money we are simply going to push the problem from one place to another.

Quite frankly we will always need more money. The challenges and prospects we face are so great that we will never have enough. But the challenge the U.S. faces right now is to its technological leadership. That leadership has been challenged repeatedly in the last 40 years, and each time government, industry and university have worked together to meet and overcome the challenge. We must do the same now.

APPENDIX D

LETTER REPORTS

"Debt Financing of Scientific Equipment," George G. Olson, Colorado State University

"Report on Shortages in Research Equipment and Instrumentation," National Institutes of Health

Thomas Kirk, Fermi National Accelerator Laboratory

ABSTRACT

DEBT FINANCING OF SCIENTIFIC EQUIPMENT

GEORGE G. OLSON, COLORADO STATE UNIVERSITY

ONE OF THE MORE CRITICAL PROBLEMS FACING THE RESEARCH ADMINISTRATOR TODAY IS THE REPLACEMENT OF RESEARCH EQUIPMENT IN UNIVERSITY LABORATORIES. THERE IS NO QUESTION THAT THE BEST SOLUTION TO THIS PROBLEM IS THE CASH PURCHASE OF NEW EQUIPMENT FROM UNIVERSITY RESOURCES, STATE APPROPRIATIONS, PROJECT FUNDS OR SPECIAL EQUIPMENT AWARDS BY FUNDING AGENCIES. WHEN THESE SOURCES ARE NOT READILY AVAILABLE, AN ALTERNATIVE CAN BE THE DEBT FINANCING OF NEW EQUIPMENT WITH THE RETIREMENT OF THAT DEBT THROUGH USE CHARGES GENERATED BY THE EQUIPMENT.

THE DEBT FINANCING OF EQUIPMENT IS MOST COMMONLY DONE THROUGH CONDITIONAL SALES CONTRACTS OR LEASE-PURCHASE CONTRACTS WITH THE VENDOR. HOWEVER, UNIVERSITIES AND PARTICULARLY STATE UNIVERSITIES HAVE AVAILABLE TO THEM A NUMBER OF OTHER SOURCES OF FINANCING THAT CAN BE USED TO FUND EQUIPMENT PURCHASES AT A GENERALLY LOWER COST THAN VENDOR FINANCED PURCHASES. THESE INCLUDE THE USE OF REVENUE BONDS, INDUSTRIAL DEVELOPMENT BONDS, MUNICIPAL LEASES AND REVOLVING LINES OF CREDIT WHERE THE INTEREST CAN BE EXEMPT FROM STATE AND FEDERAL TAXES. GENERALLY, THESE SOURCES OF FUNDS WILL NOT ONLY PROVIDE THE MEANS OF PURCHASING NEW EQUIPMENT BUT OF DOING SO AT THE LOWEST POSSIBLE COST.

TO EFFECTIVELY MANAGE AN EQUIPMENT FINANCING PROGRAM THE RESEARCH ADMINISTRATOR MUST ALSO BE A RISK MANAGER. A CAREFUL EVALUATION MUST BE MADE OF THE STABILITY OF PROGRAMS WHICH WILL BE COUNTED ON TO UTILIZE THE EQUIPMENT AND PROVIDE THE USER CHARGES. THE WILLINGNESS TO COOPERATE IN THE ACQUISITION OF A PIECE OF EQUIPMENT THAT OTHERWISE WOULD NOT BE AVAILABLE RESULTS IN A "SHARED USE" ATTITUDE WITHOUT ANY OF THE PROBLEMS ENCOUNTERED WHEN A SINGLE PROJECT FUNDS THE EQUIPMENT.

COLORADO STATE UNIVERSITY HAS FOUND IT CONVENIENT TO USE AN AFFILIATED ORGANIZATION SUCH AS A RESEARCH FOUNDATION OR INSTITUTE OR DEVELOPMENT FOUNDATION TO ASSIST IN THE FINANCING. IT IS POSSIBLE FOR THE INDEPENDENT CORPORATION (FOUNDATION) TO ENTER INTO LONG-TERM FINANCING COMMITMENTS AND THEN LEASE THE EQUIPMENT TO THE UNIVERSITY ON A YEAR TO YEAR BASIS. IN MOST INSTANCES THE EQUIPMENT ITSELF ACTS AS SECURITY FOR THE LENDER AND MOST DEBT INSTRUMENTS DO NOT REQUIRE A DOWN PAYMENT. IT IS GENERALLY POSSIBLE FOR THE ENTIRE COST OF THE EQUIPMENT TO BE MET WITH THE "USE CHARGES".

THE SELECTION OF THE APPROPRIATE DEBT INSTRUMENT IS BEST MADE IN COOPERATION WITH AN INVESTMENT BANKING FIRM AND LEGAL TAX COUNSEL EXPERIENCED IN THIS TYPE OF FINANCING. THE CONSTANTLY CHANGING TAX LAWS AND REGULATIONS AND SHIFTS IN THE MONEY MARKET MAKE IT IMPERATIVE TO INVOLVE YOUR INVESTMENT BANKER AT THE INCEPTION OF A PROJECT AND TO ASK HIS ADVICE ON APPROPRIATE LEGAL COUNSEL FOR THE TAX-EXEMPT OPINION.

INTRODUCTION

ACQUISITION OF SCIENTIFIC EQUIPMENT

NATIONAL PROBLEM - OUGHT TO BE A NATIONAL PRIORITY

UNIVERSITY PROBLEM OF OBSOLESCENCE AND REPLACEMENT

UNIVERSITY FINANCING -

FIXED INCOME AND/OR DECLINING APPROPRIATION

VS.

THE SPIRALING COST OF MODERN EQUIPMENT

UNIVERSITY LIMITATIONS ON DEBT FINANCING -

HISTORICAL

LEGAL

POLICY

STATUS OF RESEARCH EQUIPMENT

PRIOR TO THE LATE 1960s -

UNIVERSITY AND INDUSTRIAL LABS ON A PAR

RAPID ADVANCE IN TECHNOLOGY IN THE 1970s -

- LASERS, MICROPROCESSORS, FFT, SOLID STATE ELECTRONICS
- IMPROVED: PRECISION, SENSITIVITY, SPEED AND UTILITY
- INCREASED COST AT SEVERAL TIMES THE INFLATION RATE

BENEFIT - A CRYSTALLOGRAPHER'S LIFE WORK REDUCED TO ONE YEAR -

PHIL ABLESON IN SCIENCE

STATUS IN 1980 -

EXAMPLE: CHEMISTRY EQUIPMENT $/YR

ACADEMIC: 1,000 PER TENURED FACULTY AND GRADUATE STUDENT

BETTER INDUSTRIAL LABS: 15-30,000 PER STAFF MEMBER

WHY CSU

A STATE ASSISTED UNIVERSITY

(FY 81 Budget)

Research, Contracts & Grants	$ 40,000,000
Service Contracts	17,000,000
Experiment Station*	7,000,000
Tuition & Fees	28,000,000
Instructional Appropriation*	29,000,000
Extension Service*	9,000,000
State Forest Service*	2,000,000
Other, Board, Room, Auxiliary Activities, Student Aid	34,000,000
	$166,000,000

*Supported by State Appropriation

SOME YEARS NO STATE FUNDS FOR RESEARCH EQUIPMENT

AFFILIATED ORGANIZATION: CSU RESEARCH FOUNDATION, an Independent, Non-profit Corporation
Debt Management: $20,000,000

PROVIDES ACQUISITION OF:
- Farms & Ranches
- Laboratory Buildings, CDC & College Inn
- CDC 6400 Computer, NCAR Cray 1 Computer
- Satellite Tracking Station
- Aircraft
- Equipment Revolving Fund

OTHER AFFILIATED ORGANIZATIONS:
- CSU Foundation
- Research Institute of Colorado

GOVERNMENT FINANCING

FEDERAL UNIVERSITIES | STATE AGENCIES | LOCAL "AUTHORITIES"

FUNDING BASED ON THE PREMISE THAT ONE LEGISLATURE CANNOT COMMIT ANOTHER'S FUNDS

RESULTS IN THE FOLLOWING:

- FISCAL YEAR-END CLOSE OF ACCOUNTS
- EXPENSE ALL ITEMS, INCLUDING CAPITAL EXPENDITURES
- NO DEPRECIATION OR AMORTIZATION
- RESTRICTED LEASE - PURCHASE AGREEMENTS

OTHER REGULATIONS

- FPR
- ASPR
- CIRCULAR A-2L OR 73-8
- STATE AND LOCAL LEGISLATION

FUNDING NEW EQUIPMENT

1. CONTRACT OR GRANT FUNDS
2. APPROPRIATION OR ENDOWMENT FUNDS
3. SHARED PURCHASE COSTS
4. LEASING
5. CAPITAL GIFTS - ALUMNI AND CORPORATE
6. DEBT FINANCING
   - A. CONVENTIONAL
   - B. TAX EXEMPT

GOAL

1ST TO ACQUIRE

2ND TO ACQUIRE AT LOWEST COST

ACQUISITION OF SCIENTIFIC EQUIPMENT

- DEBT FINANCING

UNIVERSITIES CAN AND MUST ADOPT A BUSINESS-LIKE APPROACH TO EQUIPMENT FINANCING.

THE FREE-ENTERPRISE SYSTEM HAS DEVELOPED THE FINANCIAL MECHANISMS TO ADDRESS THIS PROBLEM.

MANAGEMENT OBJECTIVES
ASSESSMENT OF NEEDS
EVALUATE FISCAL RESOURCES
PLAN CASH MANAGEMENT
RISK MANAGEMENT
DEBT FINANCING

MECHANISMS:

REVENUE BONDS
INDUSTRIAL DEVELOPMENT BONDS
MUNICIPAL LEASES
TAX EXEMPT LINES OF CREDIT

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DEBT FINANCING ADVANTAGES

PROVIDES EQUIPMENT NOW
- SCIENTIFIC PROGRESS
- INTEREST (TAX EXEMPT) LESS THAN INFLATION

UNIVERSITY ADMINISTRATION
- BETTER MANAGEMENT
- PROGRAM AWARENESS
- SENSIBLE PLANNING

IMPROVED EQUIPMENT UTILIZATION
- SHARED USE
- CONSTANT UPGRADING
- PLANNED REPLACEMENT

DIVERSIFIED FUNDING SUPPORT
- USE CHARGE CONCEPT
- ALL AGENCIES SHARE IN COST

DEBT FINANCING

CONVENTIONAL OR NON-TAX EXEMPT

1. REVOLVING LINE OF CREDIT
2. MORTGAGE
3. LEASE AND LEASE PURCHASE
4. LEVERAGED LEASE
5. EQUIPMENT TRUSTS
6. CORPORATE BONDS
7. OTHER ASSET PLEDGING
8. SYNDICATE FINANCING
   - A. ALUMNI GROUPS
   - B. PROFESSIONAL AFFILIATIONS
   - C. LIMITED PARTNERSHIPS

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DEBT FINANCING

TAX EXEMPT OPTIONS

1. REVENUE BONDS
2. INDUSTRIAL DEVELOPMENT BONDS
3. SHORT-TERM NOTES
4. COMMERCIAL BORROWING
5. MUNICIPAL LEASE
6. PRINCIPAL GIFT AND INTEREST DEBT
7. SPECIAL AUTHORITIES

REVENUE BONDS

TAX EXEMPT - LAW, REGULATION, IRS RULING

ISSUED BY:

1. GOV'T SUBDIVISIONS

   LEVY TAXES, POLICE POWER, EMINENT DOMAIN

2. AGENCIES, 'ON BEHALF OF"

   NONPROFIT FOUNDATIONS & INSTITUTES

   BUILDING AUTHORITIES

   QUASI STATE AGENCIES

   COLLEGES AND UNIVERSITIES

CONDITIONS:

1. ISSUED FOR A PURPOSE COMPATIBLE WITH AGENCY STATED OBJECTIVES I.E. ARTICLES OF INCORPORATION
2. TITLE TO PASS TO STATE OR POLITICAL SUBDIVISION ON RETIREMENT OF BONDS
3. GENERALLY NOT APPLICABLE TO A FACILITY FOR THE BENEFIT OF THE FEDERAL GOV'T

REVENUE BONDS

MECHANISM:

IF THE STATE AGENCY CANNOT INCUR DEBT:

USE SEPARATE CORPORATE BODY

FOUNDATION

INSTITUTE

"AUTHORITY"

CORPORATION ISSUES BONDS BUT DEBT SECURITY IS SPECIFIED, I.E. FACILITY MORTAGE

TITLE MUST PASS TO POLITICAL SUBDIVISION ON RETIREMENT OF BONDS

DEBT RETIREMENT:

FUNDS FOR RETIREMENT OF BONDS COME FROM USE CHARGES FOR THE FACILITY FINANCED - MAY BE SUPPORTED BY OTHER CORPORATION FUNDS

REVENUE BOND EXAMPLE

PROJECT - CENTER FOR DISEASE CONTROL LABORATORY
COST - $1,300,000
TERMS - 12 YEARS @ 4.75% IN 1966
ISSUER - COLORADO STATE UNIVERSITY RESEARCH FOUNDATION ON BEHALF OF COLORADO STATE UNIVERSITY
AUTHORITY - IRS RULING 63-20
RENT - RESEARCH PROJECTS SUPPORTED BY FOOD & DRUG ADMINISTRATION
TERMS - PRINCIPAL, INTEREST, AND PLANT O&M APPROVED BY GSA AND FDA
TITLE - TRANSFERRED TO CSU - 1978

OTHER EXAMPLES - SAME FORMAT:
200 ACRE RESEARCH FARM
CAMPUS IRRIGATION SYSTEM
CDC-6400 COMPUTER

REVENUE BOND EXAMPLE

PROJECT - CDC 6400 COMPUTER

COST - $1,300,000

TERMS - EIGHT YEARS @ 4.7% IN 1967

ISSUER - COLORADO STATE UNIVERSITY RESEARCH FOUNDATION ON BEHALF OF COLORADO STATE UNIVERSITY

AUTHORITY - IRS RULING 63-20

USE CHARGES - RESEARCH PROJECTS, ADMINISTRATIVE COMPUTING, & INSTRUCTIONAL BUDGET

TERMS - PRINCIPAL ONLY (INTEREST PAID FROM OTHER FUNDS)

TITLE - TRANSFERRED TO CSU - 1975

OTHER EXAMPLES - SAME FORMAT:

200 ACRE RESEARCH FARM

CAMPUS IRRIGATION SYSTEM

CENTER FOR DISEASE CONTROL LABORATORY

INDUSTRIAL DEVELOPMENT BONDS

ISSUER: CITY OR COUNTY

PURPOSE: ENHANCE THE TAX BASE I.E. NEW INDUSTRY OR SUPPORT RESEARCH

DEBT RETIREMENT:

DIRECT LEASE BETWEEN COUNTY AND USER

-OR-

LEASE TO RESPONSIBLE 3RD PARTY TO GUARANTEE PAYMENT AND MANAGE DEBT

A FORM OF REVENUE BOND WITH NO OBLIGATION EXPRESS OR IMPLIED TO THE TAXPAYERS

SECURITY: LIMITED TO FACILITY FINANCED OR 3RD PARTY OR LEASEE

TAX EXEMPT BY LAW - NO IRS RULING

TITLE MAY PASS TO LESSEE OR 3RD PARTY ON DEBT RETIREMENT; NEED NOT PASS TO STATE AGENCY

INDUSTRIAL DEVELOPMENT BOND EXAMPLE

PROJECT - CRAY-1 COMPUTER FOR THE NATIONAL CENTER FOR ATMOSPHERIC RESEARCH IN BOULDER, COLORADO

COST - $9,000,000

TERMS - 10 YEARS AT 6% IN 1978

ISSUER - BOULDER COUNTY FOR COLORADO STATE UNIVERSITY RESEARCH FOUNDATION

AUTHORITY - STATE & FEDERAL IDB LAWS

RENT & A "THIRD PARTY LEASE" - CSURF PURCHASED FROM CRAY
CSURF OWNS AND LEASES TO NCAR
NCAR PAYS RENT (P&I) AND A FEE WITH 90-DAY CANCELLATION CLAUSE

ADVANTAGE OF "THIRD PARTY" - ADDITIONAL EQUITY
CREDIT REPUTATION
DEFAULT MANAGEMENT
FINANCING EXPERIENCE - TAX EXEMPT

TITLE - CSURF

OTHER EXAMPLES:

$5.3 MILLION COLLEGE INN
PENDING $2 MILLION AIRCRAFT FOR NCAR
PENDING $12-15 MILLION BUILDING FOR THE UNIVERSITY OF DENVER

MUNICIPAL LEASES

LESSEE MUST BE A POLITICAL SUBDIVISION, i.e., THE STATE UNIVERSITY NOT AN AFFILIATED CORPORATION

LESSOR - ONE OR MORE INDIVIDUAL, BANK, CORPORATION

TERM - ON A FISCAL YEAR BASIS WITH RENEWABLE OPTIONS

LIABILITY - LIMITED TO TERMS OF LEASE

RATE - MUST INDICATE PRINCIPAL AND INTEREST

TITLE - MUST PASS TO LESSEE AT COMPLETION ON A NOMINAL PAYMENT

GENERALLY MEETS A-21 REQUIREMENTS -

LESSOR - AN ARMS LENGTH AGENT

LEASE - CANCELLABLE EACH FISCAL YEAR END

SUB-LEASE - TO AFFILIATED FOUNDATION

MUNICIPAL LEASE EXAMPLE

PROJECT - SATELLITE STATION COMPUTER DATA BANK
COST - $400,000
TERMS - 6 YEARS @ 7.5% YEAR TO YEAR
LESSOR - SECURITY NATIONAL BANK THRU BOETTCHER & CO.
LESSEE - COLORADO STATE UNIVERSITY
SUB-LESSEE - CSURF
RENT - PRINCIPAL ONLY FROM ATMOSPHERIC SCIENCE DEPT. RESEARCH PROJECTS (PRIOR TO CSURF ARMS-LENGTH STATUS)
INTEREST - PAID BY CSURF FROM PATENT INCOME
SUB-LEASE - ? - TO PROVIDE ADDITIONAL SECURITY
TITLE - TO CSU

OTHER EXAMPLES - ALL INCLUDE INTEREST:

NOS COMPUTER OPERATING SYSTEM
PDP 11-70 COMPUTER
TWO WORD PROCESSING SYSTEMS
VAX-PDP 11-789 COMPUTERS
T-28 AND QUEEN AIR AIRCRAFT

TAX-EXEMPT COMMERCIAL BORROWING

SHOULD BE SUBJECT TO SIMILAR OPINIONS AND REGULATIONS AS REVENUE BONDS

ESTABLISH COMMERCIAL LINE OF CREDIT

FACILITY FINANCING BECOMES A GENERAL LIABILITY OF THE BORROWER

MOST STATE AGENCIES CANNOT BORROW THEREFORE USE A SEPARATE NON-PROFIT CORPORATION TO BORROW FUNDS

TITLE SHOULD PASS TO POLITICAL SUBDIVISION ON RETIREMENT OF DEBT

INTEREST RATE NOT FIXED - MAY FLOAT IN RELATION TO PRIME AND BE ADJUSTED ANNUALLY

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CSURF EQUIPMENT REVOLVING FUND

EXAMPLE

PROJECT	- EQUIPMENT COSTING $10,000 TO $50,000
TERMS	- 3 TO 7 YEARS DEPENDING ON PROJECT AT 8% OR PREVAILING RATE CHARGED CSURF
LESSOR	- CSURF
LESSEE	- CSU - DIRECT EXPENSE TO PROJECTS
RENTAL RATE	- PRINCIPAL AND INTEREST - CONSIDERING A FEE
SOURCE OF FUNDS	- CSURF REVOLVING LINE OF CREDIT AT COMMERCIAL BANKS
TITLE	- CSU ON COMPLETION OF RENTAL AGREEMENT

EXAMPLES:

SMALL COMPUTER EQUIPMENT
BLOOD ANALYZER
X-RAY EQUIPMENT
FARM MACHINERY
SPACE CHAMBERS
SPECTROMETERS
ETC., ETC.

PRINCIPAL GIFT - INTEREST DEBT

1. CREATE A DEBT INSTRUMENT
   BOND
   NOTE
   LEASE PARTICIPATION CERTIFICATE

2. SELL TO A DONOR - INVESTOR

3. ESTABLISH AN IRREVOCABLE CHARITABLE REMAINDER TRUST

4. PRINCIPAL GIVEN TO TRUST
   TAX DEDUCTIBLE GIFT

5. TRUST PAYS INTEREST TO INVESTOR OR DESIGNEE

6. ON MATURITY PRINCIPAL IS GIVEN TO ISSUER AND CANCELLED

EXAMPLE:

PRINCIPAL GIFT - INTEREST DEBT

ASSUME $100,000 DEBT AT 9% FOR 5 YEARS
DONOR INVESTOR - 50% TAX BRACKET

PRINCIPAL CHARITABLE GIFT	$100,000
IMMEDIATE TAX BENEFIT	50,000
TAX EXEMPT INTEREST	$ 9,000/YEAR
TOTAL INTEREST, 5 YEARS	45,000
EQUIVALENT INCOME	90,000
TOTAL BENEFIT	
INCOME DEDUCTION	$ 50,000
TAX EXEMPT INCOME	45,000
TOTAL CASH	95,000
TOTAL EQUIVALENT INCOME	$140,000

LEVERAGED LEASE

A BALANCED LEASE/FINANCING CONTRACT

INVESTOR ----- FOR PROFIT LEASING CO. ----- UNIVERSITY

INVESTOR BENEFITS:

- Investment Tax Credit
- Allowable Depreciation
- Interest Deduction
- Residual Value -- Gift or Sale

LESSEE -- Competitive Lease Cost
Title by Gift or Residual Value Purchase

In general, lease payments plus tax credits equal a better return to investor than tax exempt income -- balanced against lease costs, no greater than tax exempt financing.

PATTERNS OF EQUIPMENT USE

CONVENTIONAL FINANCING:

1. PERCEPTION OF NEED - INDIVIDUAL PI
2. USE - LIMITED TO A SINGLE LABORATORY
3. FINAL DISPOSITION - SUBJECT TO TRANSFER WITH PI OR TITLE REMAINS WITH SPONSOR

DEBT FINANCING:

1. PERCEPTION OF NEED - SEVERAL PROJECTS
2. USE - SHARED BY ALL WHO WILL PAY USE CHARGE
3. FINAL DISPOSITION - STAYS WITH UNIVERSITY

INTERNAL FINANCING

1. USER CHARGES - DIRECT OR REVOLVING FUND
2. OPERATIONAL FUNDS - APPROPRIATED OR ENDOWMENT
3. OTHER INCOME - I.E., PATENTS AND INVENTIONS
4. OVERHEAD - DEVELOPMENT OFFICE SUPPORT
5. ALUMNI-DEVELOPMENT OFFICE SUPPORT
6. SPECIFIC SPONSOR SUPPORT - I.E., 25% PER YEAR
7. OVERHEAD REBUDGETING - EXTERNAL REALLOCATION

INTEREST

ALLOWABLE:

1. APPROVED BY SPONSOR
2. MUNICIPAL LEASE
3. FOUNDATION IS ARMS LENGTH AND ISSUES OR OBTAINS
   - NOTES
   - REVENUE BONDS
   - INDUSTRIAL DEVELOPMENT BONDS
   - COMMERCIAL BORROWING
   - ANY TYPE OF DEBT (TAXABLE OR TAX EXEMPT)

   AND LEASES TO UNIVERSITY ON A YEAR TO YEAR BASIS

NOT ALLOWABLE:

UNIVERSITY ISSUED REVENUE BONDS OR OTHER DEBT INSTRUMENTS

SO . . .

PAY INTEREST SEPARATELY AND CHARGE PROJECTS PRINCIPAL ONLY

- PATENT INCOME
- GIFT INCOME
- OVERHEAD
- OTHER UNIVERSITY FUNDS

UTILIZE SEPARATE CORPORATION

INTEREST

CIRCULAR A-21 STATES:

SEC. 33-D.: WHERE SIGNIFICANT RENTAL COSTS ARE INCURRED UNDER LEASES WHICH CREATE A MATERIAL EQUITY IN THE LEASED PROPERTY, THEY ARE ALLOWABLE ONLY UP TO THE AMOUNT THAT WOULD BE ALLOWED IF THE INSTITUTION PURCHASED THE PROPERTY ON THE DATE THE LEASE AGREEMENT WAS EXECUTED. FOR THIS PURPOSE, A MATERIAL EQUITY IN THE PROPERTY EXISTS WHEN THE LEASE:

(1) IS NONCANCELABLE OR IS CANCELABLE ONLY UPON THE OCCURRENCE OF SOME REMOTE CONTINGENCY, AND

PROPOSED CHANGES TO A-21 AS REPORTED IN F.R. 47(4):932-934, OF JANUARY 7, 1982:

". . . THE COST OF INTEREST DIRECTLY ASSOCIATED WITH THE ACQUISITION OR FABRICATION OF CAPITAL EQUIPMENT ACQUIRED ON OR AFTER JULY 1, 1982, USED IN SUPPORT OF SPONSORED AGREEMENTS, IS ALLOWABLE."

NOTE: UNDERLINED PHRASE "IS ALLOWABLE" REFLECTS OMISSION WE WOULD RECOMMEND FROM THE PROPOSED MODIFICATION OF REQUIREMENTS THAT SAID CAPITAL EQUIPMENT IS "COSTING $25,000 OR MORE FOR INITIAL ACQUISITION" AND THAT IT BE ALLOWABLE "IF AGREED TO BY THE COGNIZANT AGENCY".

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NEW PROJECT EXAMPLE

PROJECT: CENTER FOR ADVANCED TECHNOLOGY

COMPUTER: CDC CYBER 205, 2 MILLION WORD, 2 PIPELINES

COST : $12,000,000
FINANCING OPTIONS: IDB, LEVERAGED LEASE

BUILDING: COMPUTER CENTER, COMPUTER SCIENCE DEPT., ETC.

COST : $12,000,000
FINANCING OPTIONS: IDB, REVENUE BOND

TELECOMMUNICATIONS SYSTEM: REPLACE BELL CENTREX

COST : $6-7,000,000
FINANCING OPTIONS: MUNICIPAL LEASE, LEVERAGED LEASE, REVENUE BOND, IDB

DOES DEBT FINANCING WORK?

IT HAS AT COLORADO STATE UNIVERSITY.

$30,000,000 IN DEBT FINANCING HAS PROVIDED:

- RESEARCH LABORATORIES
- SATELLITE TRACKING STATION
- RESEARCH AIRCRAFT
- CDC 6400 COMPUTER
- EXPERIMENTAL FARMS AND RANCHES
- VAX COMPUTERS
- CRAY-1 COMPUTER FOR NCAR
- AUGER SPECTROMETER
- ELECTRON MICROSCOPES
- MISCELLANEOUS SCIENTIFIC EQUIPMENT

AFFILIATED ORGANIZATION DEBT MANAGEMENT ROLE

1. OBTAINS DEBT FINANCING

2. ACTS AS A LESSOR ON A YEAR TO YEAR LEASE

3. ACTS AS GUARANTOR TO UNIVERSITY DEBT -
   ASSUMES DEBT ON DEFAULT
   SUB-LEASES FROM UNIVERSITY

4. ACTS AS TRUSTEE FOR PRINCIPAL GIFTS

5. PROVIDES EQUITY OR SECONDARY SECURITY

6. ACTS AS A "THIRD PARTY LESSOR" -
   ADDITIONAL SECURITY
   EQUIPMENT MANAGEMENT
   COLLECTION AND PAYING AGENT
   NOT SUBJECT TO YEARLY APPROPRIATION

7. OWNS AND MANAGES MORTGAGED PROPERTY

8. MAY OWN OR CONTROL "FOR PROFIT" ORGANIZATION

9. MEMBER OF LIMITED PARTNERSHIPS

UNIVERSITY FINANCIAL SERVICE CORPORATION

FOR PROFIT - PRIVATE CORPORATION ASSISTING CSURF

PURPOSE: TO ASSIST THE UNIVERSITY COMMUNITY:

1. FINANCING OF RESEARCH EQUIPMENT AND FACILITIES;
2. MANAGEMENT OF DEBT;
3. LICENSING AND/OR DEVELOPMENT OF PATENTS, INVENTIONS, AND COPYRIGHTS;
4. ACQUISITION OF VENTURE CAPITAL.

SERVICES:

1. CONSULTING, SEMINARS, ORGANIZATIONAL ASSISTANCE;
2. FINANCIAL PROCUREMENT;
3. LEASES;
4. SYNDICATING;
5. PATENTS AND LICENSES;
6. LEVERAGED LEASING.

TYPES OF AFFILIATED ORGANIZATIONS

NON-PROFIT OR FOR PROFIT

NON-PROFIT, IRS 501-C-3 CLASSIFICATION

CAPTIVE - CONTROLLED BY PARENT ORGANIZATION

INDEPENDENT - DEFINED BY A-21:

SEC. 33.C.: FOR THIS PURPOSE (RENTAL) A LESS-THAN-ARMS-LENGTH LEASE IS ONE UNDER WHICH ONE PARTY TO THE LEASE AGREEMENT IS ABLE TO CONTROL OR SUBSTANTIALLY INFLUENCE THE ACTIONS OF THE OTHER.

- DEFINED BY CRS 23-5-112(3):

. . . IF THE ENTITY IS ENTIRELY SEPARATE AND APART FROM THE INSTITUTION, IF NO EMPLOYEES OF THE INSTITUTION SERVE AS STAFF OR AS VOTING MEMBERS OF THE ENTITY'S BOARD AND IF THE FUNDS AND ACCOUNTS OF THE ENTITY ARE ENTIRELY SEPARATE FROM THOSE OF THE INSTITUTION . . . .

ALL-PURPOSE FOUNDATION

LIMITED PURPOSE FOUNDATION

RESEARCH INSTITUTES

FUNCTIONS OF AFFILIATED ORGANIZATIONS

1. SOLICIT GIFTS, WILLS, BEQUESTS, GRANTS-IN-AID
2. INVESTMENT MANAGEMENT AND STEWARDSHIP OF GIFTS
3. ADMINISTER RESEARCH CONTRACTS AND GRANTS
4. PERFORM A TRUSTEE FUNCTION
5. ADMINISTER PATENTS, INVENTIONS AND COPYRIGHTS
6. MANAGE REAL AND PERSONAL PROPERTY
7. ASSIST IN DEBT MANAGEMENT

*CSURF FUNCTIONS.

A WORD OF CAUTION

DON'T RELY SOLELY ON:

- THE UNIVERSITY FINANCIAL MANAGEMENT
- THE LOCAL COMMERCIAL BANK
- THE UNIVERSITY'S LEGAL COUNSEL OR THE ATTORNEY GENERAL'S OFFICE

DEBT FINANCING - A SPECIALIZED BUSINESS

- THE INVESTMENT BANKER
  - A PARTNER IN FINANCING
  - SELECTS THE PROPER INSTRUMENT
  - ADVISES ON TIMING AND THE MARKET
  - RECOMMENDS TAX COUNSEL
  - KNOWS THE INSTITUTION - HE SELLS A "STORY" BOND

  . . . DON'T OFFER TOO MUCH SECURITY

- TAX COUNSEL - TAX OPINION
  - LOCAL TAX LAW
  - FEDERAL CODE & IRS REGULATIONS
  - INTERPRETATION OF A-21, ETC.
  - LEGAL OPINIONS FOR AUDIT PURPOSES

  . . . DON'T BELIEVE EVERYTHING HE SAYS

WHAT THE FEDERAL GOVERNMENT CAN DO TO HELP

1. MAKE INTEREST COSTS ON EQUIPMENT ACQUISITION ALLOWABLE IN OMB A-21 AS PROPOSED IN JANUARY 1981 AND JANUARY 1982.

2. RECOGNIZE EQUIPMENT USE COSTS IN RESEARCH CONTRACT AND AND GRANT BUDGETS.

3. EXTEND ERTA-81 "SAFE HARBOR" LEASE PROVISIONS TO EQUIPMENT USED FOR RESEARCH AND EXPERIMENTATION. NOW LIMITED TO SEC. 38 PROPERTY AND MASS COMMUTING VEHICLES.

123

SAFE HARBOR RULES

PRIOR	ERTA-81
LESSOR 20% AT RISK	LESSOR A CORPORATION
PROFIT FROM LEASE	LESSOR 10% AT RISK
LESSEE CAN'T PURCHASE AT LESS THAN FAIR MARKET	TERM 90% USEFUL LIFE OR OR 150% ADR
LESSEE CAN'T PROVIDE FINANCING	BOTH PARTIES AGREE TO TREAT AS LEASE
USE BY OTHERS FEASIBLE	

LIMITED TO NEW SEC. 38 PROPERTY (I.E., QUALIFYING FOR ITC) AND MASS COMMUTING VEHICLES.

PROPOSED AMENDMENT WOULD ADD "AND NEW EQUIPMENT USED FOR RESEARCH AND EXPERIMENTATION".

UNIVERSITIES DO NOT QUALIFY FOR ITC AND ARE NOT ASKING FOR ITC.

JUST TREAT US LIKE A BUS!

WHAT INDUSTRY CAN DO TO HELP

1. DIRECT EQUIPMENT GRANTS
   - ERTA-81 - ALLOWS COST + 50% NORMAL MARGIN
     - INCREASES CHARITABLE DEDUCTION TO 10% NT INCOME (HISTORICALLY DID NOT REACH PREVIOUS 5%)

2. NATIONAL SCIENTIFIC EQUIPMENT TRUST
   - BUSINESS AND INDUSTRY INVEST IN THE TRUST FUND
   - TRUST PURCHASES UNIVERSITY EQUIPMENT PAPER
   - AN INTEREST PAYING INVESTMENT FOR INDUSTRY

3. NATIONAL EQUIPMENT GUARANTEE PROGRAM
   - BUSINESS AND INDUSTRY SUPPORT A CREDIT FUND
   - FUND ISSUES LETTERS OF CREDIT BACKING EQUIPMENT FINANCING
   - FUND COLLECTS 1-2% FEE FOR CREDIT
   - EQUIPMENT BONDS ARE RATED AND SOLD ON THE MARKET
   - AN INCOME PRODUCING INVESTMENT FOR INDUSTRY

REPORT ON SHORTAGES IN RESEARCH EQUIPMENT AND INSTRUMENTATION

from

The National Institutes of Health

SUMMARY

Extensive studies of the obsolence and shortage of biomedical research equipment and instrumentation over the past decade have confirmed that a growing problem exists in regard to (1) the actual supply of state-of-the-art equipment and the access of investigators to it, and (2) the development of instrumentation to utilize new technologies required for furthering advances in biomedical research.

The NIH research project system provides reasonably well for relatively inexpensive equipment which does not lend itself to shared usage. State-of-the-art instrumentation costing in excess of $30,000, which can be used by a group of investigators, is provided for NIH grantees, of whom at least half must be grantees of the National Institute of General Medical Sciences (NIGMS), through a shared instrumentation program specifically designed to support the needs of research projects in the areas of interest to NIGMS. The Division of Research Resources (DRR) also provides for shared instrumentation through institutional awards to qualified grantees. Based on recent program experience, it is estimated that approximately $20 million a year for five years is required by NIH to replenish and maintain the adequacy of the nation's biomedical research community's needs for medium-priced shared instrumentation.

The mission of the Biotechnology Research Program (BRP) of DRR is to assure the development and availability of high technology instruments that apply concepts and techniques from the physical sciences, mathematics, engineering, and computer science to biomedical research. To establish and renew state-of-the-art instrumentation so costly as to mandate sharing on a regional or national basis, it is estimated that the BRP requires additional $5 million increments each year for the next five years.

The equipment and instrumentation issues described above apply to biomedical research broadly, but some equipment and instrument needs are categor-

ical in nature and call for solutions that differ from those that respond to multicategorical needs. High technology instrument development such as that being supported by BRP requires specific fostering and combined sources of support when instrument need is categorical. A pilot series of cofunded program project grants, now being considered by NIH, should demonstrate the efficacy of this approach by promoting instrument conceptualization, prototype design, and construction, all of which serve to advance categorical research.

REPORT

The following report has been prepared by the National Institutes of Health of the Department of Health and Human Services.

BACKGROUND

During the 1960's the Federal government's support of biomedical research and development in the nation's universities fueled an unprecedented biological revolution. Research instrumentation provided an indispensable contribution to the scientists' elucidation of life processes in health and disease and the resultant new means to prevent, treat, and cure human ills. Evidence is growing steadily, however, that there is a shortage of modern equipment in laboratories conducting federally supported biomedical research. Today there is general agreement among investigators, research administrators, and officials of research funding agencies that the problem is significant.

Ten years ago the National Academy of Sciences conducted a survey of research equipment needs in a sample of large, medium, and small academic institutions. Teams of scientists were sent to examine existing resources firsthand, to interview investigators to learn what equipment was needed, and to assess the validity of the need. The survey permitted extrapolation of the findings to an estimate of the need in all academic institutions. The report, Survey of Research Equipment Needs in Ten Academic Disciplines, published in 1972, presents equipment needs for each discipline by the cost of the equipment. 1/

Smith and Karlesky, in their 1977 State of Academic Science, reported findings of major deficiencies in sophisticated instruments required for basic research in colleges and universities. 2/ In May 1980 the National

Commission on Research published a report which described the difficulties in developing and maintaining large research facilities and the problems of instrument obsolescence in the nation's research universities. 3/ Just one month later the results of a study conducted by the Association of American Universities, The Scientific Instrumentation Needs of Research Universities, were released. 4/ Most recently, in addressing a federal interagency committee that was convened by the National Science Foundation at the request of the Office of Science and Technology Policy, Dr. Kayworth characterized the research instrumentation situation in this country's universities as a "disgrace."

The cumulative and mutually reinforcing recommendations of these studies can be summarized as follows:

- The research universities, which are responsible for conducting a critical share of the nation's basic biomedical research and training, are facing serious financial difficulties in replacing worn out and obsolete equipment and in purchasing and/or developing the new instrumentation required for further research advances and state-of-the-art research training.

- During the past decade, as the competition for research funds grew ever more intense, universities made the support of the investigators and supporting staff their first priority (i.e., salaries and associated personnel expenditures). As a result of this effort to continue support for researchers, universities have been forced to further reduce expenditures for instrumentation.

- The equipment being used in the top-ranked university laboratories receiving Federal research and development funding has a median age twice that of equipment in leading industrial laboratories. Because these universities are responsible for training future investigators for science and industry, deficiencies in research equipment bode ill for future research in all settings.

- Because OMB Circular A-21 excludes depreciation on equipment purchased with Federal funds as an allowable indirect cost, a potentially important option for obtaining replacement funds is not available.

- In an age when biological research is becoming increasingly sophisticated and instrument-dependent, the Nation is rapidly losing its competitive position in biomedical research as European and Japanese laboratories expand their scope and increase their pace.

DISCUSSIONS AND RECOMMENDATIONS

The conclusions summarized above were based almost entirely on analyses of historical trends and interviews with educators, administrators, and scientists. The conclusions drawn are qualitatively sound, but more quantitative data should be sought. In the meantime, relief must be provided to remedy clearly identified problems.

The two major problems of obsolescence and shortage in research equipment for biomedical research are as follows: one is to provide investigators with access to state-of-the-art instruments; the other is to develop instruments to respond to needs for new capability and to take advantage of new technology. The projections of opportunity which follow are based, not only on perceived need, but also on what it is believed the scientific community is prepared to exploit. Each of the following budget estimates represents the professional judgment of NIH staff, and does not reflect actual future budget recommendations.

State-of-the-Art Instrumentation for Individual Laboratories

The investigator-initiated research proposal is the mainstay of the NIH extramural research program. Stabilization of this portion of the NIH activity has been given precedence over all other extramural funding obligations. In FY 1980 these awards accounted for a total of about $1.8 billion. Funding for small-scale (usually under $20,000) instrumentation required to do the work proposed, when it is not otherwise available, is provided by the award. Ultracentrifuges, refrigerated centrifuges, scintillation counters, amino acid analyzers, cell counters, infrared and ultraviolet spectrometers, x-ray diffraction equipment, and automatic sample collectors are examples of sophisticated items of equipment which do not normally lend themselves to shared usage that are funded through the research project system.

A recent study by Vener 5/ of research project grants shows that 76 percent of the sums awarded in the equipment category in FY 1979 were for less than $10,000. Almost half of the amounts awarded for equipment was in the range of $300 to $9,999. Furthermore, in a detailed study of 462 applications reviewed by 37 study sections, there was no single initial review group which appeared to systematically reduce equipment requests without scientific justification. Nor was there any systematic Institute staff reduction of the original equipment request. It is felt, therefore, that the system provides reasonably well for most instrumentation needs at the research project level.

State-of-the-Art Instrumentation Shared on an Institutional Basis

Some instrumentation can be purchased and installed for use by more than one investigator where the research need is important but intermittent, e.g., computer equipment, electron microscopes, and mass spectrometers. Decisions to select and purchase this equipment can often be made best at the local level. The Biomedical Research Support Grant (BRSG) program of the Division of Research Resource (DRR), which provides institutions with support of activities to enhance the research environment, is one mechanism which fills this need. The award is based on a formula which takes into account the institution's level of NIH research support; in this formula, the purchase of shared instrumentation is an approved activity.

However, because of the many important uses for BRSG funds and the modest size of the awards, these grants support relatively little in the purchase of major instruments for shared use. In view of this the BRSG Program initiated in 1982 a separate competitive shared instrument grant program which is described below.

Recognizing the increasing need for instrumentation, the National Institute of General Medical Sciences (NIGMS) announced in FY 1979 a shared research instrumentation program for NIH grantees, of whom at least half were required to be NIGMS grantees. Each award funded the purchase of instruments or instrument clusters with a capital cost greater than $40,000. The maximum award was limited to $150,000, included in which was $15,000 per year for a period of three years for operating and maintenance costs. Proposals requesting $26 million were received. Available funds allowed a total of approximately $9.0 million of awards to be made in FY 1979 and FY 1980. The program was reannounced in FY 1981 for instruments with a capital cost greater than $30,000 and a limit of $200,000 per award. All other features were the same. Proposals requesting $28 million were received in response to the reannouncement of the ongoing program.

In an effort to meet the needs of others in the NIH research community, DRR announced a shared instrumentation program for the purchase of equipment costing in excess of $75,000. Because DRR funds for this purpose were limited to $3.7 million, submission of only one application per qualifying institution was permitted. Despite this restriction, 205 eligible institutions applied for instrument needs totalling $39 million.

On the basis of these two recent experiences, it is estimated that the NIH community of scientists, given the opportunity, would demonstrate an overall need of approximately $100 to $150 million for shared research instrumentation. If additional funds were provided, it is estimated that NIH could award $20 million a year for five years in support of shared instrumentation to meet the very highest quality research needs.

State-of-the-Art Instrumentation Shared on a Regional or National Basis

The Biotechnology Resources Program (BRP) of the DRR, operating successfully since 1962, has demonstrated the validity of the concept of shared regional instrumentation resources. The BRP concentrates on the application of the physical sciences, mathematics, and engineering to biology and medicine. Ultrasophisticated instruments, the latest state-of-the-art methods, and expert support personnel provided by the program in installations open to many users help life scientists in their efforts to decipher fundamental biological processes or combat human illness. The program's capabilities include large-scale and minicomputer systems; biochemical and biophysical analytical instruments (mass spectrometers, nuclear magnetic resonance

spectrometers, electron spin resonance spectrometers); million-volt electron microscopes; electron microprobes; biomedical engineering technologies; and production of biochemical research materials. These capabilities are made available as resources which must be shared among a number of investigators on a national or regional level. Technological capabilities are provided in this way to overcome restraints of high cost, complexity, or scarcity affecting availability and uses of equipment required to achieve scientific progress. An NIH publication, Biotechnology Resources, 6/ describes the research resources supported by the BRP in 1981.

In order for the U.S. to maintain its preeminence in biomedical research, it must foster creativity in biotechnology and instrument development. There exist many laboratories with exceptionally talented individuals in specific areas of science, e.g., simulation systems, chemical sensor development, large scale integrated circuit design, and the use of time shared computer systems; the problem is to put this expertise to work on biologically and medically important problems. A series of workshops on Technology in Support of Biomedical Research, held at the Johns Hopkins School of Medicine in August 1981, have reaffirmed the latent capacity of the biomedical research community to expedite the transfer of concepts and techniques from the physical, mathematical and engineering sciences to applications in biology and medicine.

Continued prospects of significant fiscal restraints require that the extension of the BRP be achieved through the judicious selection and placement of resources believed to be the most promising for fostering new advances in science. It is professional judgment of the BRP staff that a modest expansion of its program by an estimated $5 million per year for the next five years is required to assure the development and availability of high technology instruments for biomedical research.

The NIH is also exploring the possibility of capitalizing on the potential to apply advanced technology in the development of new instruments for categorical research through cofunded program project grants. Joint review of each application and cofunding of each grant by DRR and the appropriate Institute would ensure that both the technical and applied facets of the proposed research could be accurately assessed and developed. For example, funding for the instrumentation core might be assumed by DRR while the Institute might support the application of the technology.

The NIH is considering a national conference in 1982 to identify the most exciting instrument modalities and configuration and to establish the criteria for their placement, management, and operation toward increasing self-sufficiency. Of necessity, this will include consideration of the most efficacious means of funding i.e., grant, contract or cooperative agreement--and the value of promoting cost sharing with industry and other federal agencies.

In addition, the NIH is considering the establishment of an NIH-wide National Biomedical Research Resources Program (NBRRP) to coordinate the development of program plans and budget strategies for the economical support of research

resources. Traditionally, virtually every component of the NIH has been involved in some way in the support of research instrumentation. And, to-date, loose coordination has been sufficient. However, in the light of an evermore stringent budget, the envisioned NBRRP may be the best means to address policies and priorities related to initiating, maintaining, or where necessary, eliminating, instrumentation programs to ensure that as many of the NIH interests as possible will be optimally served.

References

1. Survey of Research Equipment Needs in Ten Academic Disciplines, National Academy of Sciences, Washington, D.C., 1972.

2. Smith, B.L.R. and Karlesky, J.J., The State of Academic Science. Change Magazine Press, page 168, 1977.

3. Funding Mechanisms: Balancing Objectives and Resources in University Research. National Commission and Research, Washington, D.C., May 1980.

4. The Scientific Instrumentation Needs of Research Universities. A report to the National Science Foundation by the Association of American Universities, June 1980.

5. Vener, K.J., Extramural Instrumentation Funding by the National Institutes of Health, April 1981.

6. Biotechnology Resources: A Research Resources Directory. NIH Publication No. 81-1430.

Fermilab

Fermi National Accelerator Laboratory
P.O. Box 500 • Batavia, Illinois • 60510

March 22, 1982

Dr. William A. Fowler
Office of Physical Sciences
National Research Council
Assembly of Mathematical and Physical Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Dear Willy:

Your letter of March 15 arrived literally seconds after I had concluded arrangements for gathering together the information I had promised. I include it here on a separate sheet for your convenience. I hope the data is useful to you. Let me comment briefly on it.

Table I is a list of experiments that took data in this year's running period, roughly January 1, 1982 through June 1, 1982. As you can see, about twelve experiments were active. This is about half the number that we usually serve in one year, but our running period is only 22 weeks this year (due to the high cost of electricity) rather than our "normal" run of about 40 weeks per year. It is also useful to note that about two-thirds of the equipment shown in each column is reused for more than one experiment or series of experiments; in the case of modular electronics, lead glass arrays, scintillation counters, etc., the equipment can easily be useful over a ten-year period.

In Table II, I show the equipment totals along with some self-explanatory related numbers that place the equipment numbers in a (hopefully) useful context. As you can well guess, many more figures could be provided if you need them. Let me know what, if anything, would be useful.

Just a word about your meeting on March 12 and 13. I was impressed both by your organization and by the businesslike way you moved us along to a result. Not at all like the interminable haggling over minutia and the rhetorical cadenzas I was used to in academia. I felt the meeting was useful in establishing the scale of the problem and for pointing a way toward remedy. I believe the quadrapartite commission concept will be very successful in establishing the urgency of the situation, in defining meaningful steps to alleviate the equipment problem and (perhaps most important) in certifying to government leaders, from a broad spectrum of research enterprises, the seamless nature of the web

that connects and sustains research from the most abstract beginnings to the final product development, be that product a new vision of nature or a new word processor system.

It was an honor and a pleasure to be included. If I can help in any way in your subsequent work on this question, I will be happy to volunteer.

Sincerely yours,

Thomas BW Kirk
Fermilab

TABLE I

Value of Equipment Used in Fermilab Experiments[1] - January-June 1982
(thousands of US dollars)

Fermilab Experiment Number	Fermilab Supplied	University User Supplied
E-701	4331.1	445.5
E-594	2169.8	639.0
E-617	656.8	758.0
E-609	1102.0	1060.0
E-612	421.5	142.0
E-555	671.0	289.0
E-565/570	499.8	400.8
E-597	367.3	125.5
E-515	541.0	668.0
E-537	1183.8	297.0
E-615	1767.2	1530.5
E-630	601.0	252.0
	14,312.3	6,607.3

[1]Equipment funds shown here include pre-existing equipment owned by both laboratory and university users as well as new equipment purchased for the noted experiment.

TABLE II

Budget and Cost Items at Fermilab

FY82

(thousands of US dollars)

Total Laboratory Equipment Budget for Beams and Experiments		10,615
Total Laboratory Equipment Budget		18,200
Total Laboratory Operating Cost Budget		87,752
Total Capital Value of Fermilab Plant and Equipment (Approximate)		1,000,000
Total Equipment Value for Experiments		20,919
a. User Supplied	6,607	
b. Laboratory Supplied	14,312	

TABLE III

Manpower Involved in Fermilab

H.E.P. Program

FY82

Fermilab Total Employment (Approximate)		2000
Scientists	200	
Engineers	120	
Technicians	900	
Other	780	
University Users This Running Period		500
Scientists	350	
Students, Technicians and other	150	

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